REPORT

of the

DEFENSE SCIENCE BOARD

1989 SUMMER STUDY

on

NATIONAL SPACE LAUNCH STRATEGY (U)

March 1990

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION

WASHINGTON, D.C. 20301-3140

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DEFENSE SCIENCE BOARD

OFFICE OF THE SECRETARY OF DEFENSE
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11 APR 1990

MEMORANDUM FOR SECRETARY OF DEFENSE
UNDER SECRETARY OF DEFENSE FOR ACQUISITION

SUBJECT: Report of the Defense Science Board 1989 Summer Study on National Space Launch Strategy - ACTION MEMORANDUM

Attached is the final report of the Defense Science Board Summer Study on National Space Launch Strategy, chaired by Dr. Joseph F. Shea. This report addresses the shortfalls in the current National Space Launch Strategy as it applies to the Department of Defense, DoD's relationship with NASA and in particular the shuttle, and the Vandenberg AFB Shuttle Complex.

The report recommends the redirection of the Advanced Launch System (ALS) Program away from the development of a family of launch vehicles' to a joint technology program with NASA. It also recommends continued DoD support for advanced non-chemical propulsion programs because of the opportunity for a large increase in specific impulse. It provides a concept to infuse the current launch family with ALS technology and improve the current launch infrastructue. It supports the 1988 DSB Summer Study Report on Assured Military Use of Space, chaired by Dr. Robert J. Hermann in its conclusion that the warfighting CINC's require a tactical launch capability for dedicated military missions. I fully concur with the Task Force's findings and recommendations.

I recommend that you read Dr. Shea's memorandum and the specific conclusions and recommendations beginning on page 35.

John Foster Jr.

John S. Foster
Chairman

Attachment

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE BOARD

06 MAR 1990

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Report of the Defense Science Board 1989 Summer Study on National Space Launch Strategy

Attached is the final report of the 1989 Defense Science Board Summer Study on National Space Launch Strategy. This study is a follow-on to the 1988 DSB Summer Study on Assured Military Use of Space, with focus primarily on launch vehicles.

We were impressed by the growing recognition within the Government of the importance of support to our operational forces from space assets. However, we found the documents which collectively define the requirements for national security space launch strategy to be inconsistent, particularly with respect to the need for a heavy lift capability. The need to support the operational CINC's with a new class of operationally oriented satellites supported by combat capable launch vehicles is clear, although we could not find evidence of strong budgetary support for such a capability.

The Task Force was also impressed by the propulsion and vehicle technology efforts supported by the Advanced Launch System (ALS) program. We compared the benefits of developing a new launch vehicle family based on ALS technology with using that technology for product improvement to our reconstituted family of expendable launch vehicles (ELVs) - Delta, Atlas, and Titan. Although the prospect of a new family of vehicles has merit, we concluded that the existing ELVs could satisfy DoD needs well into the next century at significantly less investment during the 1990's. We, therefore, recommend a launch vehicle strategy which continues investment in advanced propulsion and vehicle technologies, supports product improvement of current vehicles, and defers any commitment to develop a new vehicle family.

The present DoD space launch mission model calls for delivery, on the average, of about 600,000 pounds per year to low earth orbit throughout the 1990's. The existing launch facilities are only capable of supporting perhaps 900,000 pounds per year because of ground support equipment and range instrumentation limitations and the checkout philosophy which has evolved over the last decade. The difference between capability and requirements is not sufficient to provide capacity for surge or recovery from launch failures. The Task Force believes that a modest investment in modernization of launch facility and range support equipment can increase the capability to over 1,500,000 pounds per year, providing a modest surge capability for recovery from launch failure, a modest growth in requirements, and the ability to support commercial space launch requirements.

The Task Force also observed that launch vehicle technology today is still based on the same chemical propulsion developed in the 1950's. Specific impulse is limited to about 465 seconds. We recommend continued investment in propulsion technologies which hold promise of much higher specific impulse, such as the hypersonic air breathing propulsion to be demonstrated by the National Aerospace Plane and, perhaps, revisiting nuclear propulsion for upper stages.

In parallel with the DSB Study, the NASA Advisory Council conducted a study of NASA launch vehicle strategy. We believe the conclusions and recommendations of the NASA study are congruent with our results. The two studies could form the basis for discussions between DoD and NASA to develop a national launch vehicle program which protects a heavy lift option for either Agency and defines a joint program in propulsion and vehicle technology which can support our national needs for space launch well into the 21st Century.

After completion of the Task Force, significant national effort has been devoted to studying requirements for President Bush's Space Exploration Initiative. If a national decision to pursue that program is made, the need for a heavy lift, high traffic vehicle may emerge. It is my opinion that the ALS technology program could form the basis for such a vehicle development. The appropriate design point might be closer to 200,000 pounds, rather than the 120,000 pounds contemplated by the ALS Program.

If a heavy lift vehicle development is initiated for SEI, the conclusions of this report would remain unchanged. The existing ELV fleet would be required to carry the national security payload requirements which are primarily below 50,000 pounds. The recommended infusion of ALS technology into Delta, Atlas, and Titan will be required to improve responsiveness, increase reliability and reduce cost.

I believe the conclusions reached by this Task Force can have significant impact on our National Launch Vehicle Strategy.

The membership of the Task Force was outstanding. I wish to thank them all, along with the support staff for their long hours and hard work in bringing this report together.

Sincerely,

Joseph F. Shea

Joseph F. Shea
Chairman

Attachment

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1.0 INTRODUCTION

A Defense Science Board Summer Study of 1989 addressed National Space Launch Strategy. The Terms of Reference (Appendix B) asked that we identify national security space launch requirements into the next century and assess today's launch systems against the operational/cost-effectiveness of feasible new launch systems and launch strategies to meet these requirements. Subsidiary issues considered were the impact of Congressional direction limiting payload weight, the performance and availability of the shuttle for DoD payloads and the applicability of DoD purchase of commercial launch services.

The study was to recommend alternative courses of action for DoD in space launch RDT&E and acquisition programs over the next five to fifteen years.

The NASA Advisory Council convened a similar effort focused primarily at the launch requirements of the civil sector. We maintained close coordination with that effort and the recommendations of both studies are complementary.

Task Force membership is provided in Appendix C.

BACKGROUND

The United States space launch capability evolved primarily from the Air Force Ballistic Missile Program which started in the mid-1950s. Product improvements were introduced into those unmanned, expendable vehicles (Thor Delta, Atlas Centaur, and the Titan family) until the mid-1970s when the administration mandated that all DoD payloads would be launched on the Space Shuttle. The impact and consequence of that decision became all too apparent after the Challenger accident in 1986.

After Challenger, DoD decided to remove virtually all national security related payloads from the shuttle. The production lines for the three major expendable launch vehicles have been reconstituted. The current national security space launch vehicles are only slightly improved over those flown in the early 1970s. However, the number of launches which can be supported per year has not yet returned to the 1970 level.

Our dependence on space for national security has increased in the 1980s. The 1988 DSB Summer Study on Assured Military Use of Space found that, over the past twenty years, the armed forces have become increasingly dependent on space systems, not just in peacetime, but for tactical operations as well. Communications, intelligence, weather, and navigation capabilities provided by satellites have become integral elements of military operations. But, our existing space infrastructure -- satellites, launch capability, and data dissemination -- is essentially peacetime oriented. Operational commanders "justifiably doubt" the survivability of the space assets in times of conflict, and are concerned about the availability of data (much of which is highly compartmented) for use by the CINCs. The 1988 study recommended that methods be developed to provide existing data in formats responsive to the needs of operational commanders; that more survivable, tactical operational space systems be developed to augment existing assets in times of crisis or conflict; and that these systems be supported by flexible launch capabilities.

This study endorses the conclusions of the 1988 effort, and focuses in more depth on the issues of space launch capability, primarily for national security payloads. Coordination with the related NASA Advisory Council Study has helped to position our recommendations within the larger national framework which includes space launch capability for NASA and the emerging commercial space industry.

In formulating our recommendations, we are aware of budgetary realities. The decade of the 1990s will be an era of increasingly tight DoD budgets. We believe our recommendations indicate a strategy which will adequately meet national security peacetime needs, address deficiencies in operational needs, and provide for the possibility of high payoff breakthroughs to meet future needs, all within an affordable funding profile.

The Task Force divided into three panels. One reviewed requirements and recommended priorities. The second studied launch vehicle options. The third addressed facility issues. The next three sections of this report cover those topics, followed by brief chapters on the subsidiary question posed in the Terms of Reference. The conclusions are addressed in the next section and the Task Force recommendations are in the final section.

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2.0 *REQUIREMENTS*

The requirements for national security space launch are contained in the following documents:

- o National Security Strategy (1985)
- o National Space Policy (1988)
- o DoD Space Policy (1987)
- o SECDEF Space Systems Study (1988)
  - -- JCS Statement of Requirements (1988)
  - -- OUSD(A) Deficiencies and Program Analysis (1989)
- o Heavy Launch Vehicle for SDI (NSDD) (1987)
- o Advanced Launch System Mission Need Statement (MNS) (1988)
- o USCINCSPACE Mission Need Statement (MNS) for Operational Launch System (in approval cycle)
- o USCINCSPACE "Assured Mission Support Space Architecture Study" (in process)
- o DoD Space Launch Mission Model through year 2000.

POLICY REQUIREMENTS

The 1985 National Security Strategy of the United States recognizes that space systems directly contribute to deterrence through critical capabilities in surveillance, communications, and navigation in support of our National Security objectives.

The 1988 National Space Policy identifies assured access to space as a key element. The fundamental goal of assured access is to enable the United States to have confidence in providing access to space when required.

When first issued in 1982, the DoD Space Policy emphasized the Shuttle as the primary launch vehicle. Revised in 1987, the policy specifies that unmanned expendable launch vehicles (ELVs) be the primary launch capability. The policy establishes that the DoD goals in space are:

- To provide operational capabilities which contribute to deterrence
- When necessary, defend against enemy attack and deny the enemy use of space
- Enhance the operations of ground, sea and air forces.

The 1987 DoD Space Policy introduced the concept of Assured Mission Capability, a balanced force structure which avoids single mode of catastrophic failure and is "sufficiently survivable" from enemy actions. The policy recognizes four components of Assured Mission Capability:

- ***Endurance***, to be achieved by proliferation and surge capability.
- ***Survivability***, through active and passive defense measures.
- ***Satellite Control***, through robust telemetry, tracking and command; increased satellite autonomy; cross links in space; and redundant, mobile ground facilities.
- ***Access to Space***, through a robust, survivable launch capability, the subject of this study.

The 1988 Space System Study directed by SECDEF resulted in the Joint Chiefs of Staff issuing a statement of requirements. For the first time, the JCS acknowledge an operational dependence on space systems, and called for the provision of -

> "assured access to space across the spectrum of conflict .... through the use of a complementary mix of launch capabilities ranging from large, heavy manned and unmanned boosters as peacetime systems to small, quick, survivable and mission effective wartime systems."

The Task Force endorses these statements of the 1988 Space Study, the 1987 DoD and 1988 National policy, and the requirements set forth in the 1988 Space System Study. To summarize, the four documents recognize the increasing utility of space assets to operational forces, the need for a more responsive peacetime and wartime capability, and the need to augment peacetime assets with operationally oriented satellites and launch capability.

SYSTEM REQUIREMENTS

The Task Force was uncomfortable with the 1987 NSDD dealing with a heavy-lift vehicle for SDI and the supporting mission need statement for ALS.

The heavy lift launch vehicle requirement for SDI was defined in a National Security Decision Directive in 1987. The mission need statement for the Advanced Launch System, approved by the Defense Acquisition Board is, to a large extent, responsive to that NSDD.

The mission need statement for the Advanced Launch System (ALS) defines a near term objective of maturing launch vehicle technologies for introduction as product improvements into the current family of launch vehicles. In the long term, it calls for a new family of launch vehicles which will be able to deliver payloads from 1,000 pounds to 220,000 pounds to low earth orbit. The system should be capable of launching a million pounds per year by the turn of the century, and five million pounds per year by 2005.

Operationally, the ALS should provide a 95% probability of launching on schedule; a 98% vehicle reliability; a surge capability of seven payloads in five days, within 30 days or less; and substitute a new payload within five days of launch. Military personnel should be capable of conducting the launch operations.

The Task Force endorses the operational requirements of the ALS MNS as reasonable goals. However, we have serious reservations about the validity of the projected growth of annual traffic requirements and the national security need for heavy payloads, and the estimates of possible cost reduction.

Figure 2.0-1 shows the current projection of expendable vehicle launches to meet DoD requirements through the year 2000. Unless there is a decision to deploy SDI, the annual national security payload to orbit averages less than 600,000 pounds. Individual payloads do not exceed 50,000 pounds. No heavy lift requirement, with the possible exception of an experiment for SDI, is evident. Figure 2.0-1 also shows the required annual traffic in pounds to low earth orbit (LEO) per year.

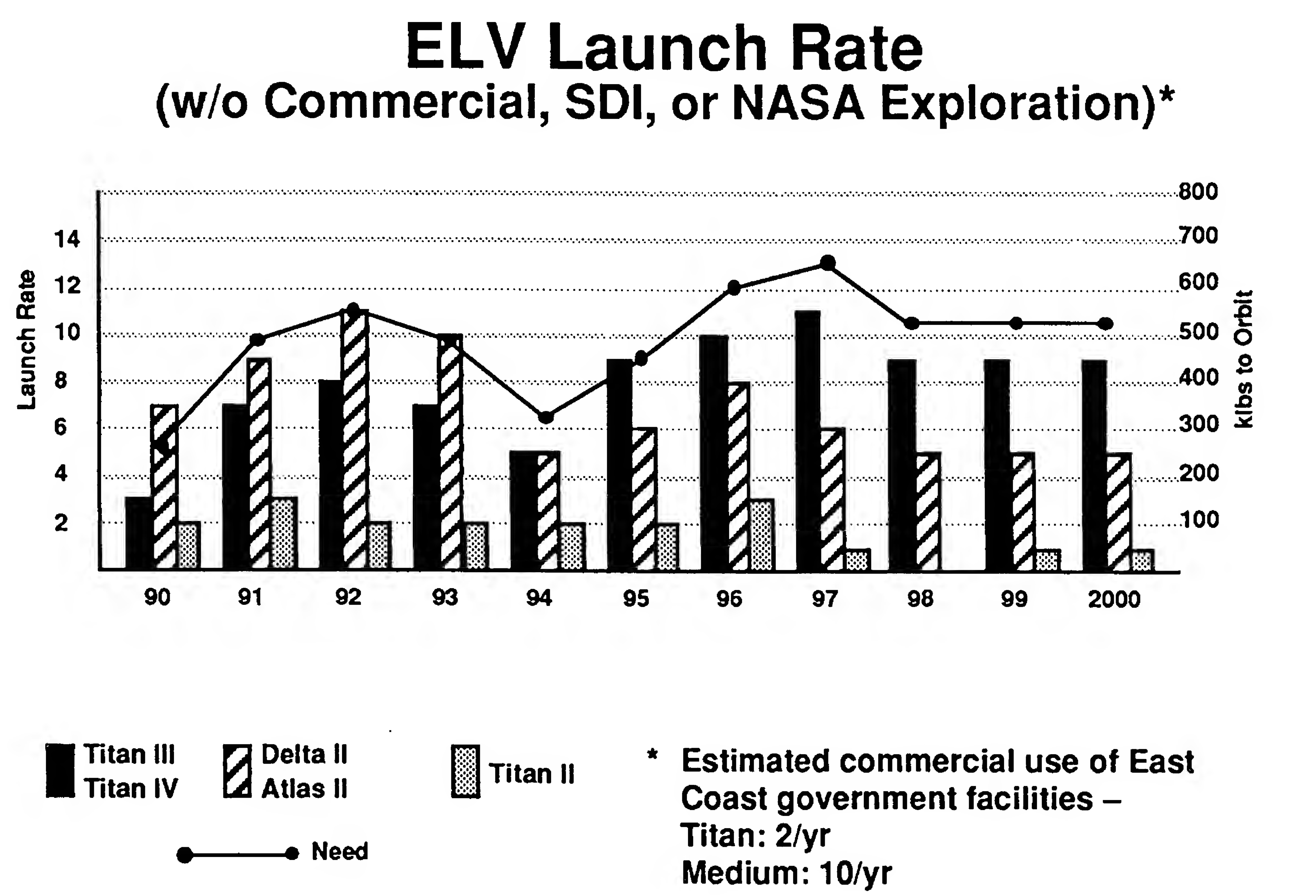

Figure 2.0-1

The national space launch capability must also support an estimated two Titan-IVs per year for civil payloads and ten medium lift launch vehicles per year for commercial payloads, and what additional NASA needs emerge that cannot be accommodated by the shuttle. Overall, without SDI deployment, annual traffic is unlikely to exceed a million pounds per year.

USCINCSPACE has proposed a Mission Need Statement for an Operational Launch System. This document complements the ALS MNS by identifying the need for operationally capable launch systems, as envisioned by the 1988 DSB Summer Study on Assured Military Use of Space. It calls for a new class of space systems; designed, acquired and operated primarily for support to military operational forces in crisis or conflict.

These new satellites must be supported by a class of light to medium payload launch vehicles with the following characteristics:

- Survivable by mobility and/or dispersal
- Capable of unconstrained azimuth and inclination launch
- Responsive launch within hours
- Standardized payload/vehicle interfaces
- Capable of being launched and operated by military crews.

OBSERVATIONS

The Task Force's review of requirements resulted in the following observations:

- Space continues to be an essential element of our national security deterrence posture.
- Our existing space launch infrastructure is principally "peacetime" oriented; perceived to be not totally responsive to broader military operational needs.

- o Our national capability must evolve to provide responsive, flexible, reliable, and survivable launch capability.

- o The requirements for heavy lift and annual traffic remain unclear.

- o The value of support from space assets to the operational forces is increasingly evident.

- o The need for a class of small, responsive vehicles to launch a new class of operational satellites is evident.

- o Standardized interfaces between launch vehicle and payload are required to provide operational responsiveness.

PRIORITIES

In light of the above observations, the Task Force believes that the National Security Launch Vehicle Strategy should embrace the following priorities.

1. Improvement of our operational peacetime capability.

   In addition to the stated requirement for increased responsiveness, other desirable goals are improved reliability, lower cost, and surge to recover from accidents and respond to crises demands.

2. Assured support from space assets to operational forces across the spectrum of conflict.

   In the near term, this can be achieved by providing access to data from existing space systems to operational commanders.[1] In the longer term, it implies a class of tactical satellites, accessible by the operational forces, supported by survivable, responsive launch vehicles capable of being operated and maintained by military crews.

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[1] As recommended in the 1988 DSB Summer Study "Assured Access to Space."

3. Heavy Lift Capability.

   Requirement for heavy lift is likely to arise in order to support either civil requirements (i.e., planetary, space station, space exploration initiative), SDI experiments, or a strategic defense system deployment. In the near term, heavy-lift requirements above those of Titan IV and Shuttle capabilities could be supported by a Shuttle derived vehicle, such as the NASA proposed Shuttle-C.

4. Investment in high payoff propulsion technology.

   The existing family of launch vehicles and the proposed Advanced Launch System are based on chemical propellants, with a specific impulse (I_{sp}) which will not exceed 465 seconds. Technologies which can provide significantly higher I_{sp}, such as hypersonic air breathing engines, nuclear propulsion, and low thrust ion propulsion could result in a new generation of significantly smaller launch vehicles for the same payload capability.

The following sections assess vehicle and facility options in light of these priorities.

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3.0 *LAUNCH VEHICLES*

The Launch Vehicle Panel reviewed the existing expendable launch vehicle program, the Advanced Launch System as proposed in mid-1989, and longer range, promising, vehicle technologies. Figure 3.0-1 shows the payload capability[2] of our existing and proposed national vehicles. Expendable vehicle capability ranges from the Scout at 500 pounds to the Titan IV at almost 50,000 pounds. The Shuttle can boost 55,000 pounds. The ALS is envisioned as a family of vehicles with payload capability from 1,000 pounds to 220,000 pounds. The chart also shows the potential capability of the Shuttle-C, an unmanned vehicle using propulsion elements derived from the shuttle which is under study by NASA. Detailed characteristics of each of these launch vehicles is provided in Appendix D.

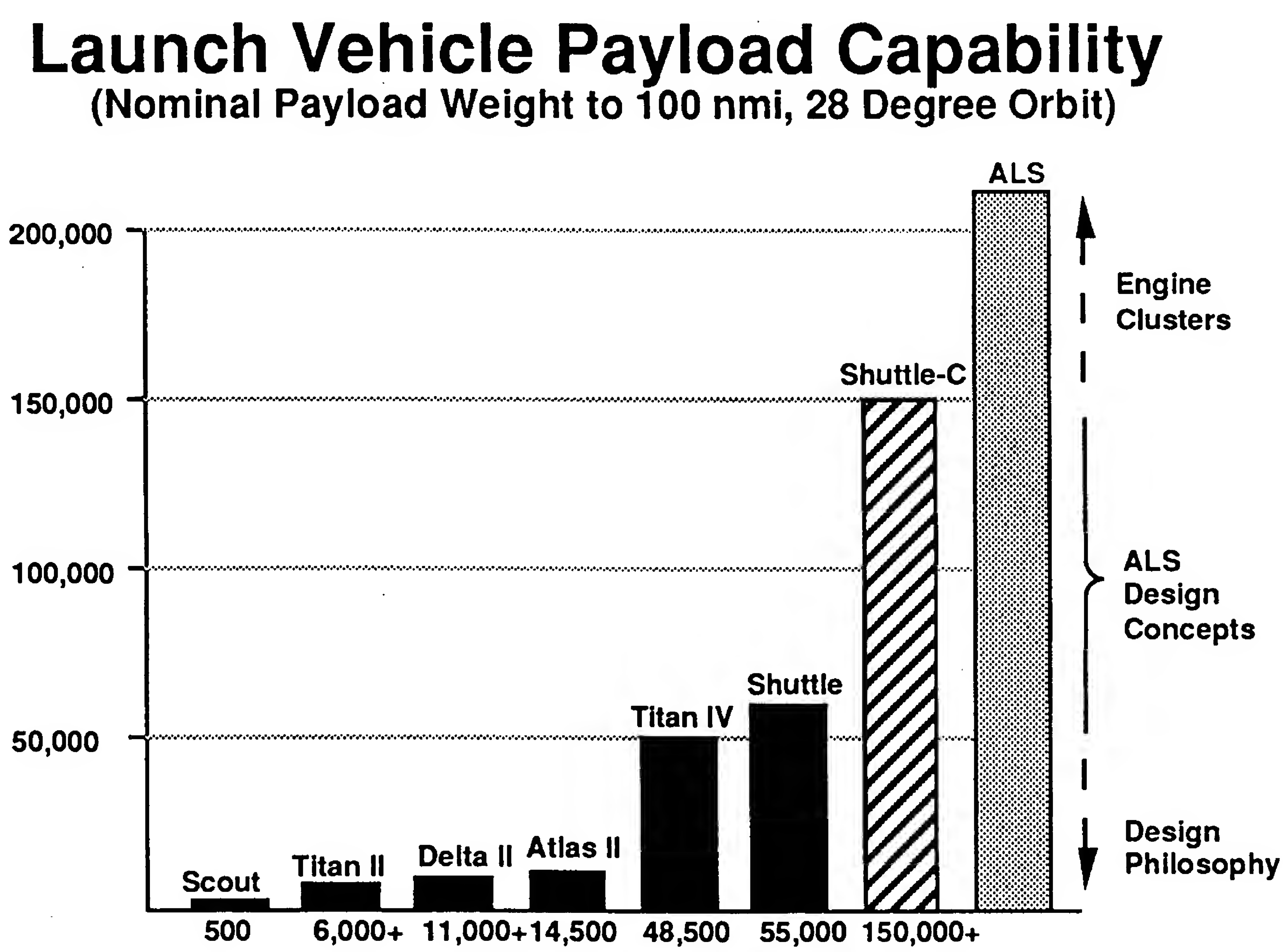

Figure 3.0-1

2 (to a nominal 100 nautical mile circular orbit due East from Cape Canaveral)

This section of the report will compare the national security launch vehicle capability which could be achieved by potential improvements to existing launch vehicles with the goals of the Advanced Launch System. We also will address the unfulfilled requirement for operational boosters, suggest an approach for providing a future heavy lift capability, and argue for continued investment in promising advanced propulsion technologies.

IMPROVEMENTS TO EXISTING LAUNCH VEHICLES

Since the Challenger accident, the expendable launch vehicle production lines have been reconstituted. Delta, Atlas Centaur, and Titan IV must provide DoD payload launch capability through the year 2000, at least. As will be discussed in the next section, the near term goal of the ALS program is to mature launch vehicle technology which can be introduced as product improvements into the existing ELV family to reduce cost, increase reliability and improve responsiveness.

Technologies applicable to cost reduction include automated manufacturing, new structural materials and processing techniques, advanced avionics, vehicle control components, and automation of payload and booster checkout operations. Technologies which can increase reliability include integrated fault tolerant avionics, electro-mechanical actuators to replace hydraulics, and automated ground support equipment.

Responsiveness can be improved by standardizing functional interfaces between vehicle and payload, and streamlining factory to pad flows to eliminate on-pad assembly operations. Automated ground support equipment, more reliable avionics and electro-mechanical controls, and use of laser-initiated pyrotechnics will all contribute to significant reductions in on-pad processing time.

Since existing ELVs must serve our launch needs for at least the next decade, this class of product improvement discussed above should be pursued. The Task Force estimates that such investment, including improvement of the launch facility infrastructure, would result in:

- o Reduction in cost of launch by at least 25% from present levels
- o Improvement in reliability from about 0.94 to, perhaps, 0.97
- o Reduction in launch processing time by at least one third (60 days out of 180 days for a Titan IV)
- o Increase, by at least 50%, in the total payload weight which can be delivered to orbit per year.

THE ADVANCED LAUNCH SYSTEM

The ALS as defined in July 1989, consists of three major parts: propulsion technology, non-propulsion technology and systems design. These efforts began in FY87 and are planned to run through FY92. Total funding over that period is projected at $929M.

The propulsion effort is focused toward establishing the technology base for the development of a 580,000 pound thrust engine. $522M is budgeted for engine trade studies, preliminary engine design, and propulsion component developments which could lead to a simpler, more producible, less costly, and more reliable engine.

The non-propulsion technology effort, budgeted at $235M, is investing in adaptive guidance, navigation and control; multipath redundant avionics; recovery and reuse of high value launch vehicle subsystems; and improved structures, materials, and manufacturing processes. The major design objectives are increased reliability, reduced vehicle manufacturing cost, and reduced pad processing time and cost.

The system design effort, budgeted at $127M, is focused on concept design of a family of launch vehicles having a payload capability to low earth orbit up to 220,000 pounds. The ALS program office presented a design point for a vehicle capable of 120,000 to low earth orbit, which appears to be the most efficient, while still allowing growth to the 220,000 pound vehicle.

The ALS system philosophy calls for modular design to provide common use of components across the family of vehicles, and reuse of high value components where it can be shown to be cost effective. Design rules emphasize increasing design margins from present practices, engine out capability, redundant avionics, and ease of manufacture. Although these would result in an increase in weight of the vehicle, they are postulated to provide higher reliability and lower cost. Simplified launch processing is predicted to improve responsiveness and reduce launch cost.

Specific goals are a launch reliability in excess of 0.98 and a order of magnitude reduction in the cost of a launch ($300 per pound of payload to orbit compared to $3,000 per pound currently for Titan IV payloads). Development cost for the ALS is estimated to be $16.5 billion, with initial operational capability by the year 2000.

OBSERVATIONS

The Task Force was impressed by the approach being pursued by the ALS program. This investment in manufacturing, propulsion, launch vehicle subsystem, and launch operations technologies should reduce cost, increase reliability, and improve responsiveness when introduced into the existing ELV fleet or used in the design of a new family of expendable vehicles. We were also impressed by the effective working relationship developed between the Air Force and NASA in the propulsion effort.

In the absence of a validated heavy lift requirement, the present design point of 120,000 pounds, with cluster capability up to 220,000 seemed too high.

Heaviest payloads in the DoD mission model are closer to 50,000 pounds. Therefore, the Task Force believes a near-term ALS capability of 50,000 or 70,000 pounds would appear more appropriate.

The ALS program office had earlier advanced an argument that significantly excess booster capacity would enable increased margins in spacecraft design, which in turn could result in radical reductions in payload cost. The Task Force was unconvinced. The same argument was offered as a justification for the lift capability of the Space Shuttle payload some twenty years ago. Projected savings in payload cost have not been realized. We believe that the payload costs are determined more by the functionality of the design and the extensive testing required to assure long life on orbit, not the weight margin available to the designer.

We also question the reality of the cost reduction goals for ALS. The factor of ten reduction postulates heavy payloads and very high annual launch rate resulting in annual traffic approaching 5,000,000 pounds. A more realistic model is ten to twelve launches per year for individual payloads of 50,000 pounds or less. The ALS will be based on essentially the same chemical propellants as the existing ELVs. We believe that at the same launch rate, a new vehicle could realistically reduce launch cost by a factor of two, and, optimistically a factor of three depending on the degree of reuse of high value subsystems. Thus, where a Titan IV launch costs about $150M today, an ALS might cost from $50M to $75M in constant dollars.

If the ALS design is down-sized, DoD then faces a choice between continuing to rely on the product improved existing ELV family into the next century or developing a new family of expendable vehicles with the ALS system philosophy. Although the new family would have many desirable features, budgetary reality may preclude the investment required during the 1990s.

As will be discussed in a later section, we believe the ALS program would better support DoD needs if it were constrained to continue to support technology insertion into Delta, Atlas, Titan and the launch facility infrastructure.

If the ALS full scale development is postponed, we believe that steps can be taken to preserve the ability to respond if a requirement for a heavy lift capability should evolve. One such step is to continue to invest in rocket engine development of the class currently being pursued by ALS.

HEAVY LIFT OPTIONS

The Task Force believes that if the rocket engines are in an advanced state of development, a launch vehicle can be developed faster than any payload it would be required to carry. Therefore, if DoD is concerned that a heavy lift capability may some day be required, it would be prudent to commit to the development of the 580,000 pound engine for which ALS has been maturing a technology base. The ALS design philosophy should be retained. The engine would provide the essential long lead item for a heavy lift vehicle. It would also have potential application to future NASA needs, and be a candidate for retrofit into Titan IV. In the near term, a requirement for a heavy lift experiment might be accommodated by the Shuttle-C, which NASA may recommend to meet their requirements.

OPERATIONAL BOOSTERS

Assured access to data from space by operational forces is a new element of our national security space capability. Investment will be required in a new class of small, operationally focused satellites, a flexible launch capability, and mobile, redundant, ground terminals which can be accessed by deployed forces. DoD must develop a Space Systems Architecture, responsive to CINC requirements, to assure effective integration of satellite, launch vehicle, and ground facilities. A key element of that architecture is the definition of the tactical, near real time, information needs.[3]

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[3] USCINCSPACE is conducting a study "Assured Mission Support Space Architecture," scheduled for completion in early 1990.

The Task Force believes that satellites weighing from 500 pounds to 2,000 pounds might satisfy these requirements.

Two approaches to survivable, flexible launch vehicles in this class were reviewed and show enough promise to warrant further study. One is the use of existing ballistic missiles which are being phased out of the operational inventory. Both silo and submarine based ballistic missiles should be available. If arms control implications can be solved, use of these existing assets might prove to be the least costly approach to providing a capability.

An alternate possibility is to pursue the current DARPA initiatives regarding launch vehicles. Pegasus, which was initiated with significant private investment, should soon attempt its initial launch. Pegasus promises a relatively low cost capability for payloads up to 800 pounds. Launch from an aircraft should increase flexibility in choice of orbit. DARPA also is pursuing the Standard Small Launch Vehicle (SSLV), or Taurus, which is planned to satisfy requirements up to 2,000 pounds.

NEW TECHNICAL APPROACHES

All of the vehicles discussed thus far rely on conventional chemical propellants. For engines which burn liquids, the maximum specific impulse (I_{sp}) is about 465 seconds. For solids, I_{sp} is limited to about 260 seconds. For a given payload and orbit, specific impulse determines the quantity of fuel which must be carried, and is one the factors in determining the size of the launch vehicle. As we approach the end of the twentieth century, all operational space launch vehicle designs are based on propulsion technology which originated in the 1950s.

The Task Force reviewed two technical approaches which hold promise for a breakthrough in achievable specific impulse.

The hypersonic air breathing propulsion technology incorporated in the National Aerospace Plane (NASP) can develop a specific impulse above 1,000 seconds, and approach 3,000 seconds, in the flight regime between Mach 3 to about Mach 17. We strongly endorse the decision, supported by the recent

National Space Council recommendation, to continue the NASP technology development as a joint Air Force/NASA program. We also strongly support investing in the X-30 flight vehicle to demonstrate hypersonic air breathing propulsion when the present program has matured the technology as far as ground testing will permit.

The Task Force believes that the most important part of the NASP program is the development of air breathing hypersonic propulsion, not the demonstration of a single stage to orbit vehicle. The single stage to orbit concept has been oversold. Air breathing propulsion will have several applications, from rockets to aircraft. In particular, we recommend that more attention be applied to studying this technology for upper stages of a multi-stage launch vehicle.

Nuclear propulsion promises specific impulse above 800 seconds. Although launching rockets incorporating nuclear devices presents emotional and political difficulties, the Task Force review leads us to recommend continued investment in this area. With the renewed interest in manned exploration of the solar system, this technology may ultimately be of even more interest to NASA than to DoD.

While recommending continued strong support for both of these propulsion technologies, we recognize the difficulty of sustaining a commitment to concepts with a long range payoff in times of tight budgets. The history of our national launch vehicles is replete with promising programs which have been started, made progress, then stopped because no real term operational need could be justified. We believe the future of our nation in space in the twenty-first century depends, in part, on sustained commitment to potential "breakthrough" propulsion concepts.

4.0 *FACILITIES*

As the production lines for a family of expendable launch vehicles are reconstituted, the number of launches per year which can be sustained is limited by throughput at our Eastern and Western test ranges. As detailed in Appendix E, Delta is supported by two pads at Cape Canaveral and one at Vandenberg; Atlas Centaur by two pads at Canaveral; and Titan IV by two pads at Canaveral and one at Vandenberg. The facility panel reviewed the limitations of our present launch capability and concluded that supporting the mission model is in jeopardy unless significant improvements are made in processing vehicles and payloads for launch.

CURRENT FACILITY CAPABILITIES

The ballistic missiles, from which our present space launch vehicles derived, were designed to be launched operationally in minutes. Development test programs in the late fifties and sixties sustained launch rates of two or more per month. It is ironic that over the last decade, pad processing time has become excessive. Figure 4.0-1 shows a Titan IV processing flow at the Western Test Range. Time on pad is almost six months.

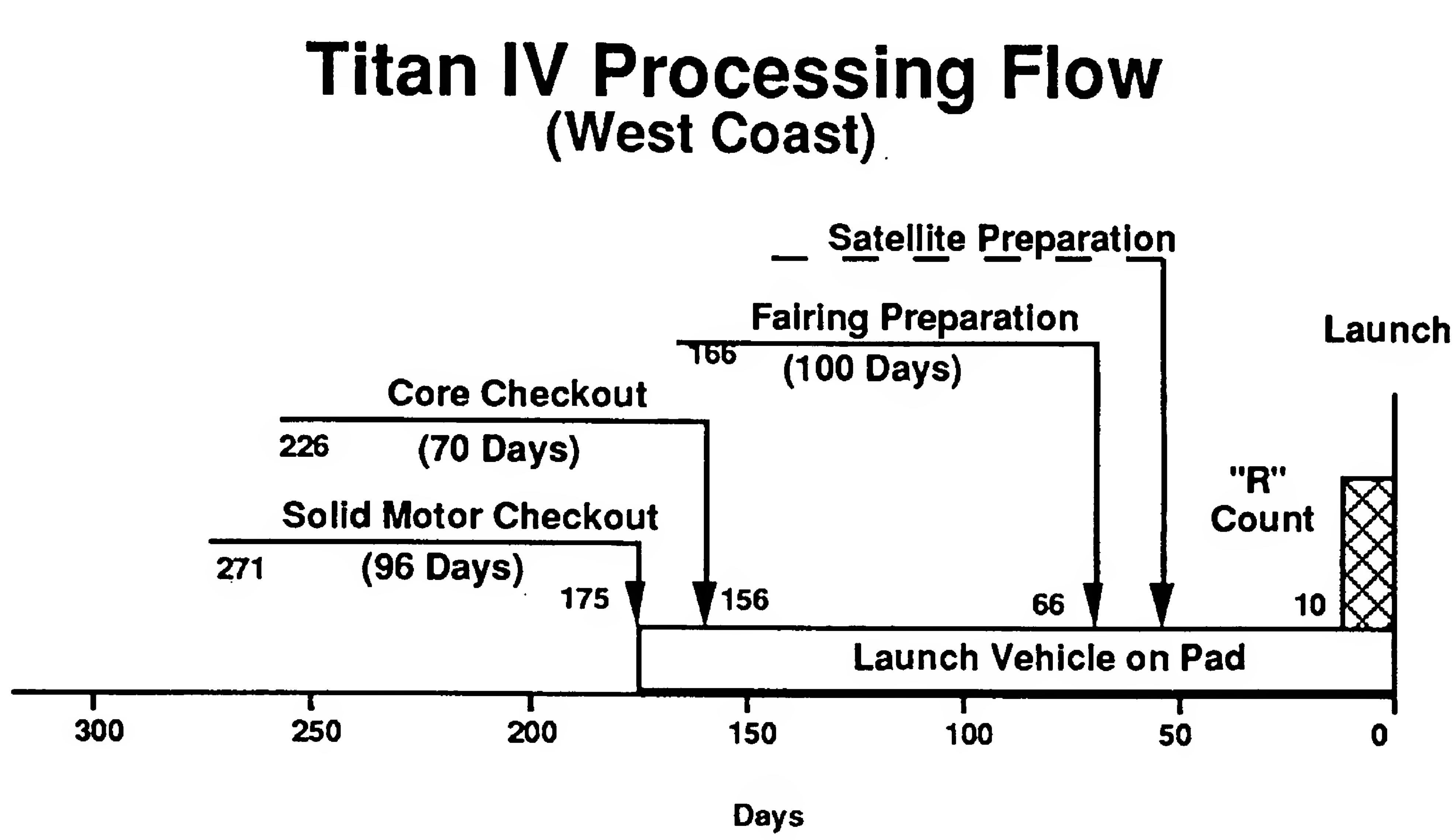


Figure 4.0-1

The present launch facility capability is non responsive, even to our peacetime national security needs. Confidence in being able to launch on schedule is low. There is little flexibility to change payloads or move a payload from one vehicle to another.

Ground support equipment and facilities to check out vehicle and payload, and the range instrumentation required to support checkout testing and launch are antiquated. The launch infrastructure has suffered from lack of product improvement over the last decade, reflecting the decision to phase out the expendable launch vehicles and rely on the shuttle for all DoD payloads.

The single Titan IV pad at Vandenberg is a major risk. Payloads to polar orbit can only be launched from the West Coast, and the April 1986 Titan 34D accident demonstrated how much damage can be done to a launch complex by a booster malfunction.

Physical security at the launch sites is poor, particularly at Cape Canaveral. Concern for assured access to space would argue for increased protection to guard against the threat of sabotage.

The Task Force believes that it will be relatively straightforward to improve throughput at our launch facilities. Both the rate and schedule of launches required by the DoD mission model can be assured, with sufficient extra capacity to provide a surge capability to recover from accidents or respond to crises, and accommodate reasonable projections of commercial launch demand.

We believe this can be accomplished by changing the checkout philosophy of the vehicle and payload. The present approach is a natural outgrowth of the relatively low ELV launch rate of the past 15 years. The system accommodates as much time on the pad as is available. What is needed is a return to the launch approach which was developed in the 1960s and later discontinued.

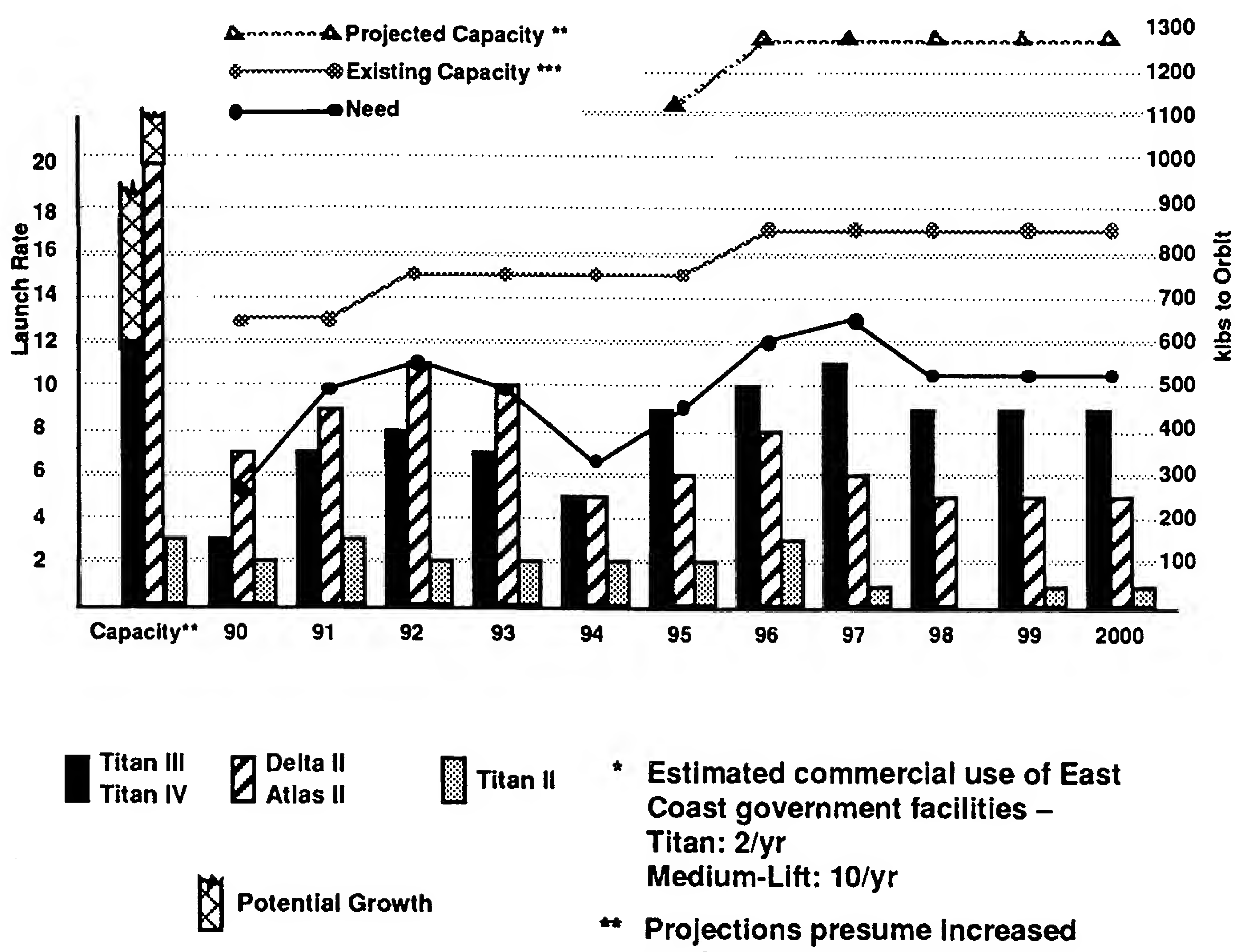
Pad check out time can be shortened significantly if vehicle and payload are completely checked out at the factory, and a factory to pad concept implemented. Modernized ground support equipment and range instrumentation can also streamline check out and countdown timelines. Telemetry and remote wideband communications can enable complex payloads to be checked out by the same support equipment used in the factory.

We noted that as the launch vehicle production lines are being restarted, there has been a tendency to ship short from the factory and finish assembly on the pad. On pad time will decrease when programs require delivery of a complete vehicle and availability of adequate spares at the launch complex.

The Task Force believes that such a change in check out philosophy coupled with a modest investment in modernizing ground support facilities, can result in a dramatic reduction in the time spent on the pad. Current timelines should be reduced by at least 60 days for Titan, and a factor of two reduction would seem to be an achievable goal.

Figure 4.0-2 depicts the projected ELV launch capacity resulting from investments in reliability, launch processing, and production capacity in the Atlas II, Delta II, and Titan III/IV programs. The increase in lift capacity to approximately 1.3 million pounds per year would, for the remainder of the decade, appear to satisfy any foreseeable growth in DoD requirements and leave ample capacity for whatever commercial demand emerges.

ELV Launch Capacity Projection
(w/o Commercial, SDI, or NASA Exploration)*



* Estimated commercial use of East Coast government facilities –
Titan: 2/yr
Medium-Lift: 10/yr

** Projections presume increased production capacity and improvements in processing and reliability

*** With additional Titan IV pad at WTR

Figure 4.0-2

5.0 *A POSSIBLE NATIONAL LAUNCH VEHICLE STRATEGY*

This section will discuss the launch vehicle options available to support assured access to space into the next century.

Launch vehicles can be divided, somewhat arbitrarily, into three classes:

- o Small: vehicles primarily to support the proposed new class of tactical satellites. Payload capability to low earth orbit should range from 500 pounds to about 3,000 pounds.
- o Medium: vehicles primarily to support satellites which support our existing national security space requirements. Payload capability to low earth orbit should range from about 10,000 pounds to around 50,000 pounds.
- o Heavy: vehicles primarily to support possible new missions, such as some versions of SDI deployment, possible NASA needs to support the Space Station, and/or the emerging new initiative for manned exploration of the solar system. Payload capability to low earth orbit should range from about 100,000 pounds to perhaps 250,000 pounds.

SMALL VEHICLES

This requirement can be satisfied in two different ways:

(1) Utilize surplus TRIAD assets. Some silo-based Air Force ballistic missiles and Navy Fleet Ballistic Missiles (FBM) will be retired from the operational strategic forces over the next several years. These missiles are survivable, and the FBMs are mobile. Payload capability to low earth orbit is in excess of 2,000 pounds. Use of these existing assets to launch tactical satellites should minimize vehicle development and acquisition costs. A major problem is the arms control implications of launching vehicles which have previously been designated as nuclear weapons carriers. That issue must be resolved, and an operationally

responsive command and control structure defined, before any decision to rely on this approach can be made.

(2) Develop the family of mobile, quickly deployable vehicles which DARPA has initiated. These include the air launched Pegasus, which is designed to inject about 1,000 pounds into low earth orbit, and the Standard Small Launch Vehicle (SSLV), derived from Peacekeeper and Pegasus, which can inject up to 3,000 pounds.

The Task Force believes further study of these two alternatives is required so that performance, cost per launch and operational advantage can be determined.

MEDIUM VEHICLES

This requirement can also be satisfied in one of two ways:

(1) Rely on the existing ELV family, with product improvements introduced from the continuing ALS vehicle technology program. This should result in vehicles with 25% lower cost and reliability approaching 0.97. Launch facility improvements, as discussed in the preceding section, should improve annual launch rate capability to over 18 for Titan IV, and over 30 for Delta and Atlas. As shown in Figure 4.0-2, this is more than adequate to satisfy projected national security traffic requirements with ample space capacity to fulfill surge and commercial launch needs. Payload capacity would range from about 10,000 pounds for Delta to over 50,000 pounds for a product improved Titan IV.

(2) Reorient the ALS program to provide a family of vehicles with payload capability from about 10,000 pounds to perhaps 70,000 pounds. Using the ALS design philosophy, and new technology, these vehicles could reduce the cost of launch by at least a factor of two, at most a factor of three, at equivalent traffic levels. Modern launch facilities could meet any reasonable launch rate requirement. Reliability could exceed 0.98. The 20,000 pound increase in maximum payload weight could provide additional flexibility in payload design.

The Task Force recognizes that a new generation of space launch vehicles would provide lower cost, higher reliability and greatly improve responsiveness. If the DoD budget could sustain the investment required in the 1990s, the ALS family would be an attractive option entering the next century. The estimated development cost is about $16 billion, with a peak funding rate of over $3 billion per year.

We have attempted to quantify the benefits of this new family compared to investing in product improvement of the existing ELVs. A Titan IV launch today costs about $150 million. With injection of ALS vehicle technology, the cost of a Titan IV should approach $112.5M, a 25% reduction. Reliability should exceed 0.96. We estimate that such product improvements might total about $700 million for vehicle modernization and reliability enhancements. Improvement of the launch infrastructure is estimated at an additional $650 million. Continuation of the ALS vehicle technology program from 1992 to 1997 is roughly another $160 million per year, or about $1 billion.

Improvements to Delta and Atlas might total less than $350M. Delta, Atlas, and Titan must be supported until the ALS becomes operational. The total cost of product improvements to extend their utility beyond the year 2000 totals about $2.7 billion, of which a large fraction should be spent to improve the performance of the existing fleet in the 1990s.

If ALS meets its goals, beginning in 2000, the cost of a launch equivalent to a Titan IV would be $50 million, a factor of three less than today's cost. Reliability would exceed 0.98. Assuming an average of 10 Titan IV equivalent launches per year, launch cost would be reduced by $625M (112.5 - 50 = 62.5 x 10) per year. Launch failures would be reduced from roughly one every two years to one every four years. Assuming a payload value of as much as $1 billion, that amortizes to an additional $250M per year, for a total savings of $875M per year. The difference in investment during the 1990s to achieve that saving is on the order of $13 billion ($16B-$2.7B).

The annual savings projected by this analysis (which is optimistic in favor of a new ALS family) are less than the interest which might be earned by prudent investment of that difference.

This type of economic analysis is not usually applied to DoD investment. But it forms a backdrop for our recommendation. The product improved ELV fleet can meet the nation's needs for medium launch capability. The gains promised by ALS are not dramatic in light of the investment required. A relatively small fraction of the difference in investment could be used to address the deficiencies in tactical capability, heavy lift, and promising new technologies.

HEAVY LIFT

The Task Force has not identified a requirement for high traffic, heavy lift capability. Requirements may emerge from DoD for isolated SDI experiments or from NASA for relatively low rate launches to support assembly of the Space Station or the initial phases of manned solar system exploration. DoD may wish to provide an option to meet a future requirement for high traffic, heavy lift payloads.

The Task Force recommends that Shuttle-C, with a capability of 150,000 pounds to orbit, and a launch rate of 3 to 6 per year, or some equivalent vehicle derived from existing propulsion systems, can satisfy that need. Insurance against the need for a high traffic requirement can be provided by investing in development, at least to prototype stages, of the 580,000 pound thrust engine which ALS technology is now supporting.

LAUNCH STRATEGY

The Task Force did not study in depth the issues of launch strategy: reconstitution, on-orbit sparing, launch-on-need vs. launch-on-schedule. In this area, we would tend to reinforce the conclusion of the 1988 Summer Study which might be summarized as:

(1) Certain assets on orbit are reasonably survivable. Attrition, if any, will take weeks to months, not days.

(2) Launch-on-schedule will gradually build up assets on orbit, because satellite life historically exceeds prediction.

(3) Store-on-orbit may be desirable for a selected sub-set of national assets.

(4) Launch-on-demand, in time of crisis, of "tactical" satellites is very effective.

SUMMARY

Based on the discussion above, the Task Force proposes the following national booster technology and acquisition strategy.

(1) DoD redirect the ALS program to provide technology insertion to the existing ELV fleet and launch infrastructure. Delay any decision to develop an ALS family until trades with advanced technology options can be evaluated.

(2) DoD continue to study the tradeoffs between using available TRIAD assets or the DARPA initiated small launch vehicle for tactical payloads. Continue the DARPA programs to determine feasibility of new small vehicle design.

(3) DoD develop a joint program with NASA to provide heavy lift options. NASA should assume the lead responsibility for the Shuttle-C equivalent vehicle to meet NASA needs for Shuttle upgrades, Space Station support, and future manned exploration of the solar system. NASA should also support development of the 580,000 pound thrust development to protect the high traffic, heavy lift option.

(4) DoD should continue to support the potential breakthrough propulsion technologies, as an added component within the ALS program. Inclusion within the ALS program will ensure the greatest integration of these advanced propulsion technologies with the chemical rocket engine baseline (i.e., 580K) .

The resultant investment required is shown in Figure 5.0-1.

Notional Investment Plan (FY 92-97)

(Non-recurring Cost)

	92	93	94	95	96	97	Total
Titan Programs							
• System Modernization Reliability Enhancements	110	160	160	120	85	50	685
• Launch Infrastructure Enhancements	145	260	180	40	15	10	650
Medium Launch Vehicles	75	80	80	60	40	TBD	335+
"ALS"							
• Propulsion							
• 580K Engine	100	100	100	100	100	100	600
• Other (High Isp)	115	135	150	150	TBD	TBD	550+
• Nonpropulsion	60	60	60	60	60	60	360
• Vehicle Concepts	15	15	15	15	15	15	90
Sub-Total	620	810	745	545	315+	235+	$3.27+ B
Operationally Responsive Booster *	50	100	200	100	50	25	525
Total	670	910	945	645	365+	260+	$3.795+ B

* Developmental costs only

Figure 5.0-1

6.0 *SUBSIDIARY ISSUES*

The Task Force was also asked to review four subsidiary issues:

- o Titan Launch Facilities at WTR
- o Congressional direction limiting payload weight
- o Performance capability and availability of the Shuttle for DoD payloads
- o Applicability of DoD purchasing commercial launch services.

The ensuing paragraphs contain our observations on these topics.

TITAN LAUNCH FACILITIES AT THE WESTERN TEST RANGE

The Terms of Reference asked for a recommendation between the conversion of Space Launch Complex SLC-6 from a Shuttle facility to a Titan IV facility and the construction of a new Titan IV facility, SLC-7. As noted in the facilities discussion, the single Titan IV launch facility at Vandenberg represents a considerable risk to assured access to space. We strongly recommend investment in a second Titan IV launch complex at the Western Test Range for both the capacity increase and redundancy it would provide. The Air Force studies we reviewed indicated that the converted shuttle facility could be available somewhat earlier than a new complex, at a cost of about $600M, some $200M lower than the estimate for the new facility designed specifically for Titan IV.

The Task Force did not find a compelling argument for either choice. The schedule difference is not significant. We suspect that the cost difference may not be as large as presently estimated, given the complexity of converting an existing facility to a new vehicle, and may in fact prove not to be any cheaper than building a new pad. However, using SLC-6 would, in a sense, use a capability which represents a major national investment.

Developing a new facility for Titan IV would provide an opportunity to incorporate elements of the new philosophical approach to check out discussed earlier. The facility, at relatively little increase in cost, could be sized to handle a heavy lift vehicle of over 100,000 pounds. Continuing the mothball status of SLC-6 would preserve the capability to launch either the Shuttle or the Shuttle-C into polar orbit should that need arise in the future.

The arguments are qualitative. On balance, the Task Force found the case for Space Launch Complex-7 more compelling. We strongly recommend investment in a second Titan IV launch complex at the Western Test Range for both the capacity increase and redundancy it would provide.

PAYLOAD DESIGN

The National Defense Authorization Act for Fiscal Year 1989 (Appendix A) directs that all future satellite related research and development programs should be guided by the following principles.

> "First, the initial research and development request for a new satellite, or a block change for an existing satellite, shall be accompanied by documentation indicating that the initiative is driven by validated military requirements, that the DoD has determined that the improvement is cost-effective and that the implications for launch support have been considered."

This basically asks DoD to practice prudent management of new space initiatives. The studies requested should be major considerations in the Defense Acquisition Board review of new programs.

> "Second, the Under Secretary of Defense for Acquisition shall not approve for development a new satellite if the proposed payload weight exceeds 85% of the lift capability of the launch vehicle(s) identified within the proposed satellite, and shall not approve for development a block change if the proposed payload weight exceeds the weight of the existing payload."

A 15% weight margin at the initiation of a new satellite development is reasonable. Again, Congress is asking DoD to exercise prudent technical management practices. However, we strongly disagree with limiting block changes to the weight of the existing payload. Such an arbitrary limit could lead to unsound programmatic decisions. We suggest that each case be studied on its merit, as required by the first Congressional recommendation.

DoD USE OF THE SHUTTLE

After the Challenger accident, DoD use of the Shuttle was reviewed at the National, DoD, and Air Force levels. The conclusion in all three cases is that the Nation is best served by a mixed fleet of manned and unmanned launch systems, and that the DoD should only use the Shuttle when the unique attributes of a manned system are needed or where it is cost effective.

As a result of this policy decision, the DoD has initiated actions to move all its operational payloads off the Shuttle. This transition will effectively be completed by 1992. Several payloads that are configured for Shuttle deployment will be launched on the shuttle in 1989-1991, but DoD has advised NASA that following the last DoD mission in FY91 (STS-46), there will be no further requirement for secure missions. Future use of the Shuttle will be limited to unclassified R&D flights and operational flights which require the unique attributes of a manned vehicle.

With few exceptions, DoD capability to launch on the Shuttle will degrade over time, as the configurations of the spacecraft are optimized for expendable launch vehicles. However, prior to 1992, the GPS, DSP, and DSCS satellites could be launched on the Shuttle in the event of an emergency.

The Task Force unanimously supports the current DoD policy with respect to use of the Shuttle. A more in-depth discussion on this subject is provided in Appendix G.

DoD USE OF COMMERCIAL LAUNCH SERVICES

We were asked to study "the applicability of DoD's purchasing commercial launch services in lieu of normal acquisition of launch vehicles." "Commercial launch services" implies that an industrial contractor will guarantee to place a given payload on orbit. As the study progressed, it became clear that the demand for launching commercial payloads alone could not support our launch vehicle industry. The DoD traffic is essential to the maintenance of economic production lines for Delta, Atlas, and Titan.

The Task Force had reservations about DoD purchasing commercial launch services. Although such an approach may be warranted in selected cases, applying the concept of commercial launch services across the board would have the effect of the DoD relinquishing control over access to space to the commercial sector. The commercial launch services market currently operates on the margin of the needs and infrastructure developed by the DoD and NASA. The stability of the commercial launch services sector, in the absence of the DoD infrastructure is not yet established. Since this concept of purchasing commercial services is relatively new, the Task Force believes that the trade-offs and applicability on use of commercial services deserves more thorough study before a firm position can be developed

7.0 *CONCLUSIONS*

Based on the preceding discussion, the Task Force reached the following conclusions:

- The current national security space launch strategy is piecemeal. There is no consistent statement of requirements in the documents dealing with National Security Space Launch.
- In the absence of a decision to deploy SDI, there is no identified DoD requirement for a heavy lift vehicle.
- If the required rocket engines are in an advanced state of development, the schedule required to develop a heavy lift vehicle can match the availability of any payload it would launch.
- The propulsion and vehicle technology supported by the Advanced Launch System Program shows promise of improving the reliability and lowering the cost of launch vehicles.
- For a reasonable investment in product improvement for the vehicles and upgrades to existing launch facilities, the reconstituted family of expendable launch vehicles can satisfy current DoD traffic and payload requirements well into the next century.
- Product improvement of the existing ELV fleet is significantly more cost effective than development of a new family. Any commitment to develop a new family of launch vehicles should be delayed until the feasibility and cost benefits of the new technologies can be assessed.
- Having only one Titan IV launch facility on the West Coast is a major risk.
- Increased emphasis should be placed on assuring support to operational forces from space assets, in peace and war.
- New propulsion technologies which promise specific impulse much higher than that achievable by conventional chemical propellants should be supported.

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8.0 RECOMMENDATIONS

The Defense Science Board Summer Study on National Security Space Launch Strategy recommends:

- That the Secretary of Defense develop and promulgate a National Security Space Launch Strategy that articulates a consistent statement of all military space launch requirements.

- That the Under Secretary of Defense (Acquisition) redirect the Advanced Launch Vehicle Program. The investment in propulsion and vehicle technology should continue, directed at introducing product improvements into the existing launch vehicles (Delta, Atlas, and Titan). Commitment to develop a new family of launch vehicles should be deferred.

- That the Deputy Secretary of Defense assess whether a DoD need for a heavy lift mission capability is likely to arise. To protect against such a contingency, he can initiate a joint NASA/DoD program to develop the 580,000 pound thrust engine which has been the focus of the ALS propulsion technology.

- That the Secretary of the Air Force initiate a program to upgrade our national launch facility infrastructure and checkout philosophy. The goal should be to increase launch rate capability by a factor of two. He should also invest in a second Titan IV pad at the Western Test Range.

- That CINCSPACE define the system architecture to provide assured support to operational forces from space assets.

- That the Under Secretary of Defense (Acquisition) develop or procure responsive small boosters to support a new class of operationally oriented satellites.

- That the Under Secretary of Defense (Acquisition) support the National Aerospace Plane hypersonic air breathing propulsion technology through demonstration in the proposed X-vehicle. He should also continue investigation of promising emerging propulsion and vehicle concepts.

- That the Deputy Secretary of Defense initiate discussions with NASA to develop a national long range advanced technology program for vehicles, propulsion and facilities to anticipate the needs of DoD, NASA, and the emerging commercial space industry well into the twenty-first century.

APPENDIXICES

APPENDIX A

NATIONAL DEFENSE AUTHORIZATION ACT 1989

Calendar No. 646

100th Congress 2d Session	SENATE	Report 100-326

NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 1989

REPORT

[TO ACCOMPANY S. 2355]

ON

AUTHORIZING APPROPRIATIONS FOR FISCAL YEAR 1989 FOR MILITARY ACTIVITIES OF THE DEPARTMENT OF DEFENSE, FOR MILITARY CONSTRUCTION, AND FOR DEFENSE ACTIVITIES OF THE DEPARTMENT OF ENERGY, TO PRESCRIBE PERSONNEL STRENGTHS FOR SUCH FISCAL YEAR FOR THE ARMED FORCES, AND FOR OTHER PURPOSES

TOGETHER WITH

ADDITIONAL AND SUPPLEMENTAL VIEWS

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

MAY 4, 1988.—Ordered to be printed
Filed under authority of the order of the Senate of April 27 (legislative day, April 25), 1988

U.S. GOVERNMENT PRINTING OFFICE
84-827 WASHINGTON : 1988

SPACE LAUNCH RECOVERY

During the past year, the estimated cost of the Department of Defense space launch recovery program through fiscal year 1994 has increased from $5.9 billion to $11.7 billion. These changes have resulted primarily from changes in the assumptions about the availability and performance of the space shuttle, which, since December 1986, have had the net effect of removing 18 of 36 payloads from the shuttle through 1995. The over $5 billion additional cost to DOD has resulted from the need to procure boosters—and the production and launch rate capabilities required—for payloads previously planned for shuttle launch.

The committee supported last year, and continues to support the development of redundant space launch capabilities so that the United States will never again be dependent for space access on a single vehicle type. The space launch recovery effort will result in a number of expendable launch vehicles, ensuring that failure of a single booster type will not ground all satellite programs. Moreover, it is hoped that improved fault detection and instrumentation capabilities will reduce the amount of down time should boosters experience failures in the future. Nevertheless, there is little prospect that individual satellites will enjoy space launch redundancy until the Advanced Launch System (ALS) is available late in the next decade. The committee believes strongly that a central focus of the ALS program should be to break from the current situation that ties satellites to specific launch vehicles and requires months of costly pre-launch preparation that also limits ability to replace critical satellites on demand in a timely manner.

As a result of availability and performance considerations, and the National Aeronautics and Space Administration's (NASA) desire to work off the backlog of non-DOD payloads, the current shuttle manifest for DOD shows only Strategic Defense Initiative (SDI) and Research and Development related flights with unique manned requirements after 1992. In view of the immense DOD investment in the shuttle, the committee believes that a very thorough review of the long term prospects for future DOD utilization of the shuttle is required before any actions are taken that would preclude use of the shuttle from either coast after 1995. A reporting requirement to this end is described below. In a related action, the committee recommended a prohibition on the expenditure of any funds for the proposed new Titan IV pad at Vandenberg pending completion of the shuttle utilization study.

The fiscal year 1989 budget request contains funding to expand the production of Titan IV boosters and to improve their performance; expand the launch rate capabilities for Titan IV boosters; and to develop and competitively procure a new class of boosters—the Medium Launch Vehicle (MLV) II—to launch the Defense Satellite Communications System (DSCS). After exhaustive review, the committee is convinced of the relative unattractiveness of alternatives to satisfy those requirements. Consequently, the committee approves the basic program presented in the fiscal year 1989 request, and the related fiscal year 1988 reprogramming request. The committee recommended a reduction of $50 million in the procurement request for the MLV II program in anticipation of contract savings resulting from the competition. Should these savings not be realized, the committee would invite reprogramming action to restore the necessary funding.

The committee notes that the Solid Rocket Motor Upgrade program provides an opportunity for redundancy in providing solid rocket motors for the Titan IV program. The committee encourages the Department of Defense to maintain two sources for production of motors if this can be demonstrated to be cost effective.

The committee also has reviewed aspects of the recently enunciated national space policy and has noted the emphasis on encouragement of commercialization and privatization of space launch boosters, manufacturing facilities, and launch facilities. The committee encourages a robust commercial launch industry, recognizing the inherent advantages to the DOD in lowering the cost of boosters through economies of scale and providing alternative access to space in emergencies. The committee will monitor carefully the relationship of DOD launch programs with commercial programs to ensure that defense function funds are not subsidizing commercial activities.

The Air Force, by policy and practice, has been the executive agent for providing DOD space launch services. The Navy, in contrast, plans to procure launch services for the Ultra High Frequency (UHF) follow-on satellite, taking delivery of the satellite on orbit. The committee is concerned that the Navy will pay a substantial premium for risk assumption on the part of the contractor. Moreover, the UHF follow-on will be compatible with existing or programmed Air Force boosters. Therefore, the committee directs the DOD to have the Air Force assume responsibility for providing launch of the UHF follow-on satellite.

Finally, the committee notes several tendencies in recent years that have contributed to the difficulties of restoring assured access to space. The first is a tendency to design satellite payloads to the limits of promised launch vehicle performance capability. In the case of the shuttle, where promised performance has been degraded as a result of post-Challenger changes, or never realized in the first place, the result has been payloads intended for shuttle launch that now must be launched on expendable launch vehicles. The MILSTAR satellite is another example. Designed to the weight limits of the Titan IV booster, MILSTAR weight growth may now require the performance improvement of the Solid Rocket Motor Upgrade in order to reach the desired orbit.

The second tendency is to upgrade satellites between each block change, which also increases the weight of the payloads. The focus of these improvements has been survivability and reliability related, which the committee supports. However, the committee is concerned that these improvements are not in all cases driven by validated military requirements, nor subject to the degree of scrutiny within the Department of Defense as would be warranted by the cost of the programs involved and their implications for space launch support. In a related action taken for budgetary reasons, the committee recommended a $10 million undistributed reduction against the research and development requests for the DSCS, Defense Support Program (DSP), Defense Meteorological Satellite Program (DMSP) and Global Positioning System (GPS) programs.

As a consequence of the experience noted above, the committee believes that all future satellite related research and development programs should be guided by the following principles. First, the initial research and development request for a new satellite, or a block change for an existing satellite, shall be accompanied by documentation indicating that the initiative is driven by validated military requirements, that the DOD has determined that the improvement is cost-effective, and that the implications for launch support have been considered. Second, the Under Secretary of Defense for Acquisition shall not approve for development a new satellite if the proposed payload weight exceeds 85 percent of the lift capacity of the launch vehicle(s) identified with the proposed satellite, and shall not approve for development a block change if the proposed payload weight exceeds the weight of the existing payload.

Reporting Requirements

In view of the tremendous investment that the DOD has already made in the space shuttle program, the committee believes a very detailed review of future DOD use of the shuttle is warranted. The committee therefore directs the Secretary of Defense to request the Defense Science Board to review DOD space launch requirements in the mid-to-late 1990s to determine whether the shuttle should be included in the array of space launch vehicles for the DOD. The review should include, but not be limited to, an assessment of the performance and availability of the shuttle for DOD payloads (to include an assessment of shuttle performance improvements such as the Advanced Solid Rocket Motor); an assessment of the comparable launch costs using the shuttle versus expendable launch vehicles; an assessment of the alternatives for disposition of the Vandenberg Shuttle Complex given the above findings; and an assessment of DOD plans in the near term—through 1995, with respect to providing cost effective assured access to space. The Defense Science Board review shall be submitted to the Committees on Armed Services of the Senate and House of Representatives not later than March 1, 1989.

APPENDIX B

TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301

ACQUISITION

27 MAR 1989

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference - Defense Science Board Task Force Review of National Space Launch Strategy

You are requested to organize a Defense Science Board Task Force to review our national security space launch strategy. Because of the large investment made by the DoD as part of the space launch recovery plan and subsequent decisions, it is appropriate to review rigorously the various launch programs, both manned and unmanned, and to understand how they contribute to the requirement for assured access to space as called for in both National and DoD Space Policy. There is also particular concern over DoD's planned use of a manned system in the long term.

The Task Force should review DoD's strategy for space launch and make recommendations on (1) alternative approaches to space launch across the range of national security payloads and (2) DoD's development and acquisition programs in space launch. This review should include recent and planned DoD initiatives aimed at improving space launch capability and addressing the requirement for assured access to space. Your baseline should be the current DoD Space Launch Recovery Program. Specific aspects to be covered include:

a. Assess national security space launch requirements into the next century (both with and without a strategic defense) and the ability of currently programmed launch assets (boosters and upper stages) to meet these requirements. This assessment should also include the production and facility capacity to satisfy these requirements.

b. Assess the operational/cost-effectiveness of the full set of feasible launch systems (today's launchers and possible new systems, including modular designs) as well as launch strategies (e.g., reconstitution, on-orbit sparing, launch-on-need) available to DoD.

c. Assess the impacts of the recent Congressional direction limiting payload weight to 85 percent of booster performance, considering the current philosophy of dedicating specific boosters to payloads, usually with little performance margin.

d. Assess the performance and availability of the shuttle for DoD payloads to support assured access to space requirements. This includes both current performance levels and funded improvements, such as the Advanced Solid Rocket Motor, plus evolutionary derivatives.

e. Determine the applicability of the DoD's purchasing commercial launch services in lieu of the normal acquisition of launch vehicles, including the identification of specific programs that lend themselves to purchasing a commercial launch service.

f. Where deficiencies occur, identify and prioritize alternatives (technical, programmatic, and policy) to satisfy deficiencies. These should not be limited strictly to hardware, but also to launch and payload operations.

g. Based on the above, recommend alternative course(s) of action for DoD in its space launch RDT&E and acquisition programs over the next five to fifteen years.

While a number of studies have looked at specific elements of the US space launch inventory, this study is to look across all national security needs.

Additionally, I understand that the NASA Advisory Council (NAC) is convening a similar effort focused primarily at the civil sector. It is clear that it would be in the Administration's best interest to ensure that the NAC and DSB efforts are fully coordinated. Therefore I request that the DSB establish with the NAC a formal process to address the coordination of both efforts.

The Deputy Director of Defense Research and Engineering, Strategic and Theater Nuclear Forces, will sponsor this Task Force. Dr. Joseph Shea will serve as Chairman. Mr. Dennis J. Granato, ODDDRE/S&TNF(O&SS) will be the Executive secretary, and Commander George A. Mikolai, USN, will be the DSB Secretariat representative. It is not anticipated that your inquiry will need to go into any "particular matters" within the meaning of Section 208 of Title 18, USC.

APPENDIX C

DSB NATIONAL SPACE LAUNCH STRATEGY

MEMBERSHIP

DSB NATIONAL SPACE LAUNCH STRATEGY

TASK FORCE

Dr. Joseph Shea, Chairman

REQUIRMENTS
R. Dougherty (Chmn)
I. Bennett
W. Cockell
A. Baciocco

VEH/TECH
G. Paulikas (Chmn)
D. Fink
R. Burnett
A. Flax
G. Clark
B. Schriever
R. DeLauer

FACILITIES
R. Jacobson (Chmn)
R. Fuhrman
C. Cook

EXECUTIVE SECRETARY: D. Granato
DSB: LCDR S. Wiley
SUPPORT: R. O'Rourke, J. Rowley

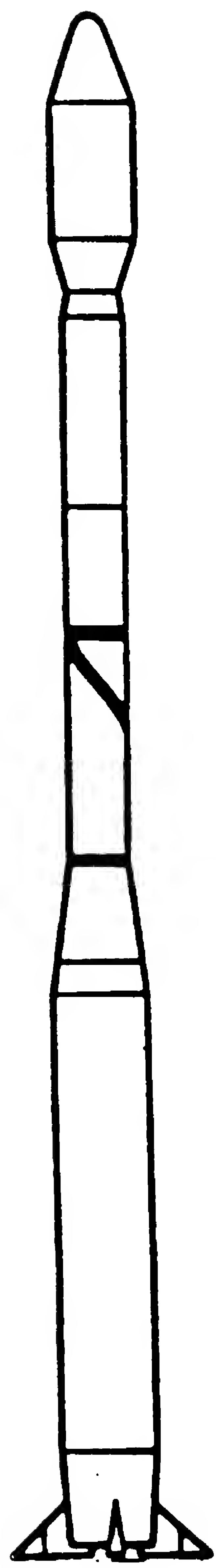
ADVISORS:

USA:	R. Norwood
USAF:	Col R. Dickman, USAF
SDIO:	LtCol G. Payton, USAF
JOINT STAFF (J-8):	LTC D. Ross, USA; Capt C. Lowery, USAF
OASD(C3I):	LtCol J. Shaver, USAF
USCINCSPACE(J-5):	BG D. Lionetti, USA; LtCol T. O'Brien, USAF
NASA:	J. Bain

APPENDIX D

LAUNCH SYSTEM CHARACTERISTICS

SCOUT



Height (ft)	75.4
Weight (lbs)	47,000
Liftoff Thrust (lbs)	96,900

Stage V
Mage-2 solid propellant motors
(other parameters TBD)

Stage IV	
Height (ft)	4.0
Diameter (ft)	2.1
Thrust (lbs)	5,800

Stage III	
Height (ft)	11.2
Diameter (ft)	2.5
Thrust (lbs)	18,700

Stage II	
Height (ft)	20.7
Diameter (ft)	2.6
Thrust (lbs)	64,100

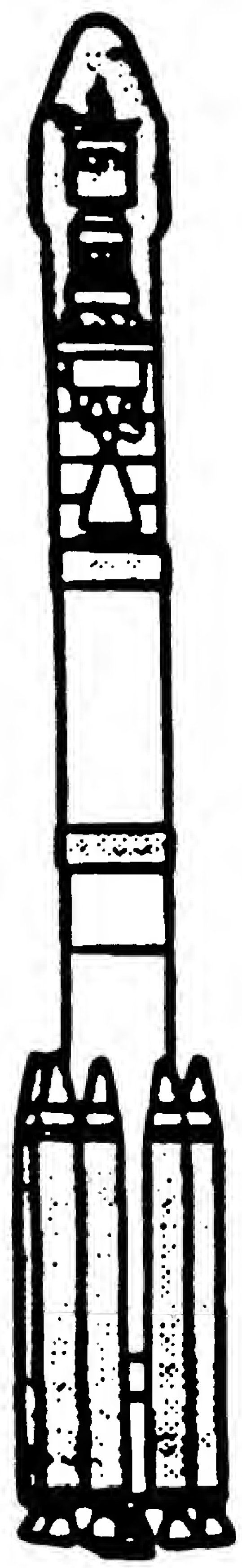
Stage I	
Height (ft)	30.8
Diameter (ft)	3.8
Thrust (lbs)	96,900

Payloads: Navy, scientific, probe, and re-entry spacecraft

100NM Polar (lbs)	460
100NM Due East (lbs)	570

The Scout is the smallest US launch vehicle. The standard Scout Launch Vehicle is a solid propellant, four stage booster system, which provides efficient launch for small spacecraft. LTV Corporation is the prime contractor to NASA for the Scout Launch Vehicle. The Scout is capable of orbital and suborbital missions. A standard fifth stage is available for highly elliptical and polar orbit missions. In its typical four-stage configuration, it weighs 40,000 pounds and develops 96,900 pounds of thrust at liftoff. The Scout is now being offered as a commercial SLV.

DELTA II



Height (ft)	125.9
Weight (lbs)	
Liftoff Thrust (lbs)	849,000
Stage III - PAM (Optional)	
Height (ft)	7.1
Diameter (ft)	4.0
Thrust (lbs)	15,000
Stage II	
Height (ft)	19.5
Diameter (ft)	6.0
Thrust (lbs)	9,580
Stage I	
Height (ft) (6925)	87.0
Height (ft) (7925)	99.0
Diameter (ft)	8.0
Thrust (lbs) (6925)	207,000
Thrust (lbs) (7925)	201,000

Solid Rocket Motors

Stage II	
Height (ft) (6925)	36.6
Height (ft) (7925)	42.6
Diameter (ft)	3.0
Thrust (lbs) (6925)	108,000
Thrust (lbs) (7925)	115,000

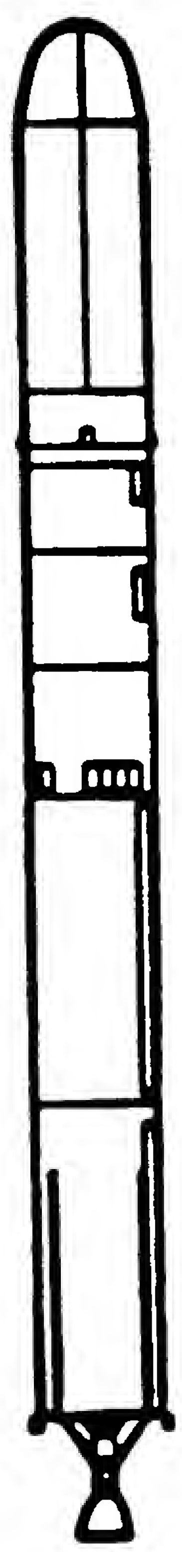
Payloads: Delta II, Mode is 6925 and 7925 - GPS, SDI, NASA, Model 7925 only - NATO IV A (1990)

GTO: (LBS)	(6925)	3,190
	(7925)	4,010
100NM Polar:	((6925)	6,670
	(7925)	8,420
100NM Due East:	(6925)	8,780
	(7925)	11,110

The original Delta was created by NASA as an intermediate launch vehicle consisting of a Thor first stage and upper stages from the Vanguard program. From this baseline configuration, the Delta vehicle has progressed through a series of modifications to increase its payload capabilities. The Air Force currently plans to purchase 20 Delta II vehicles to launch the Global Positioning System (GPS) satellite into semi-synchronous orbit. The specifications above are for the Delta II Models 6925 and 7925. The second version of the Delta II will feature new composite SRMs, which are six feet longer, lighter, and as strong as their steel counterparts. Additionally, the main engine will feature an increased expansion ratio nozzle, to increase its thrust rating.

The manufacturer of the Delta II is McDonnell Douglas. The above figure depicts the Delta Numerical Designation Key (i.e., 6925, 7925, etc.).

TITAN II

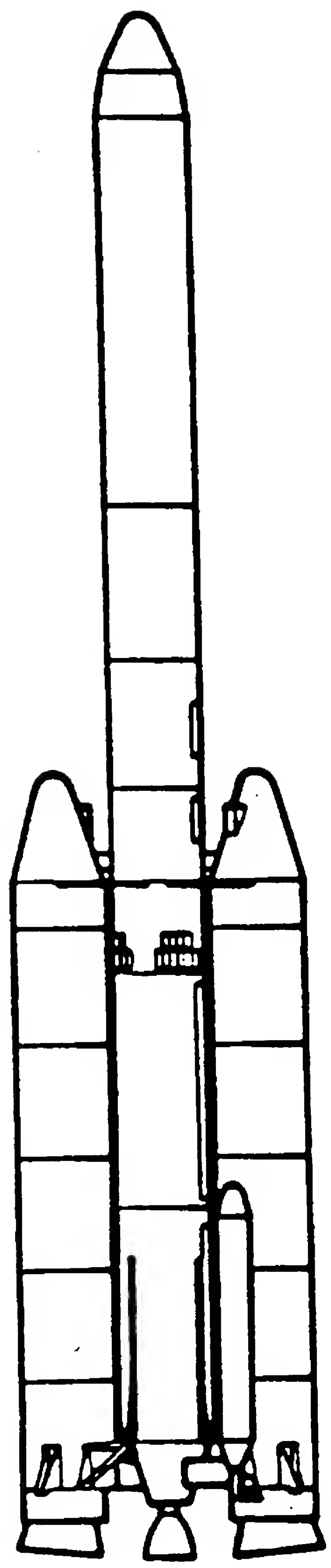


Height (ft)	140.0
Weight (lbs)	340,000
Liftoff Thrust (lbs)	430,000
Payload Fairing	
Diameter (ft)	10.0
Lengths (ft)	20 to 30
Stage II	
Height (ft)	4.0
Diameter (ft)	10.0
Thrust (lbs)	100,000
Stage I	
Height (ft)	70.0
Diameter (ft)	10.0
Thrust (lbs)	430,000

Payload: DMSP, NOAA, Classified Programs
100NM Polar (lbs) 4,800

Titan II space launch vehicles are converted Titan II ICBMs modified by use of the Titan III payload fairing, attitude control system, and electrical and destruct package. A total of 47 Titan II vehicles are currently in storage at Norton AFB, California. The USAF has 14 ICBMs under contract for conversion into launch vehicles. Of those 14, one is at VAFB, eight at Martin Marietta, and five remain at Norton AFB

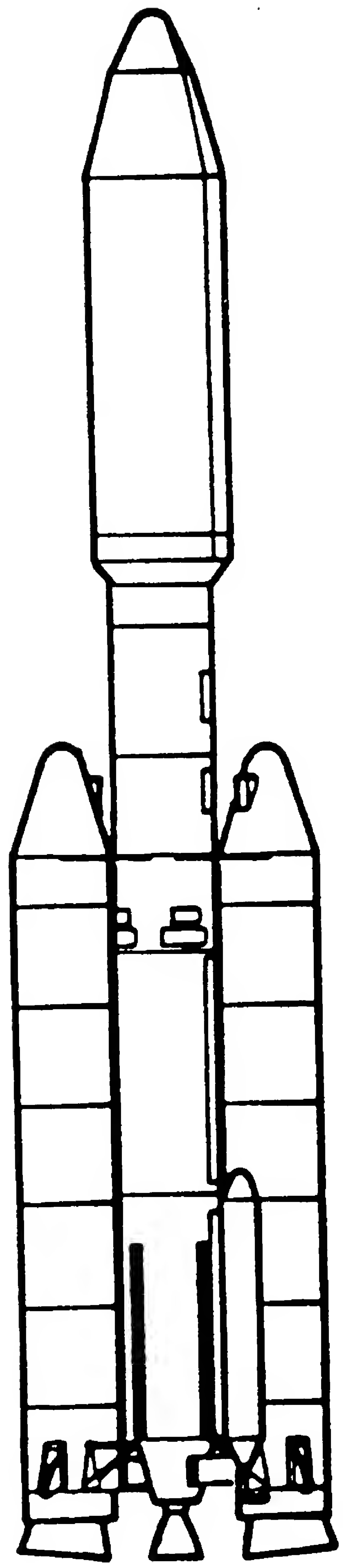
TITAN 34D



Height (ft)	Up to	161.9
Weight (lbs)	Up to	1,519,600
Liftoff Thrust (lbs)		2,800,000
Payload Fairing		
Diameter (ft)		10.0
Lengths (ft)		15 to 60
or		
Diameter (ft)		10.5
Lengths (ft)		40 to 55
Stage II		
Height (ft)		31.0
Diameter (ft)		10.0
Thrust (lbs)		101,000
Stage I		
Height (ft)		77.8
Diameter (ft)		10.0
Thrust (lbs)		529,000
Solid Rocket Motors		2
Height (ft)		90.4
Diameter (ft)		10.2
Thrust (lbs ea)		1,400,000
Payloads: DSP, DSCS, Other		
LEO (lbs)		31,650
GEO (lbs)		4,200
100NM Polar (lbs)		27,000

Several different varieties of the Titan launch vehicle have evolved over the years. The Titan III was the first Air Force vehicle specifically designed and developed as a space launch vehicle. The current workhorse of the Titan family is the Titan 34D, which was developed as a replacement for the Titan III series. Only four Titan 34D launch vehicles remain in the inventory. The Titan 34D launch vehicle consists of three elements: liquid propellant core engines, Solid Rocket Motors (SRMs) for thrust during boost phase, and one of several upper stage configurations - Centaur, Inertial Upper Stage (IUS), Transtage (Titan 34D only), or No Upper Stage (NUS). The Titan space launch vehicles are manufactured by Martin Marietta.

TITAN III



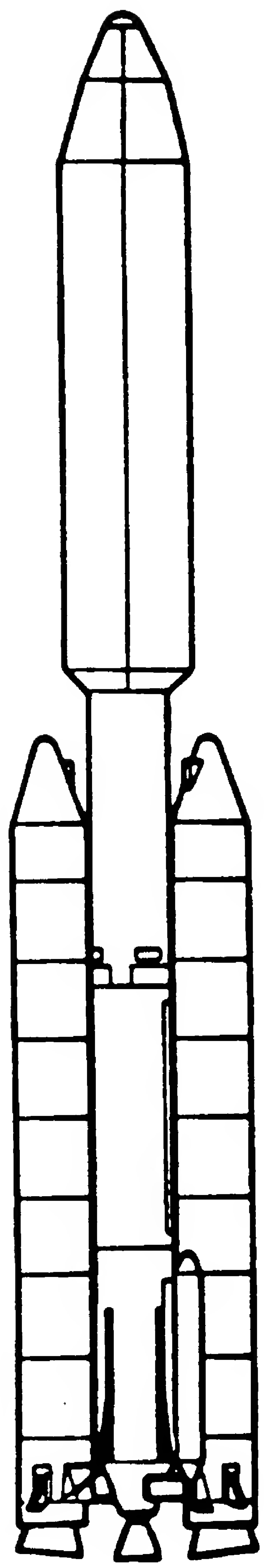
Height (ft)	150
Weight (lbs)	1,500,000
Liftoff Thrust (lbs)	3,350,000
AFT Payload Carriet	
Length (ft)	18.3 (LEO)
	16.0 (GTO)
Diameter (ft)	13.1
Payload Fairing and Extension Module	
Length (ft)	up to 52.5
Diameter (ft)	13.1
Stage II	
Height (ft)	32.7
Diameter (ft)	10.0
Thrust (lbs)	104,000
Stage I	
Height (ft)	78.6
Diameter (ft)	10.0
Thrust (lbs)	546,000
Solid Rocket Motors	2
Height (ft)	90.4
Diameter (ft)	10.2
Thrust (lbs ea)	1,396,000 each
Total - (lbs)	2,792,000

Payloads: JCSAT-2, INTELSAT, and GE satellite (commercial satellites)

LEO (lbs)	31,000

The Titan III began service in 1964 and has delivered more than 200 payloads into Earth orbits and missions to the sun and planets of the solar system. Titan IIIs were used to launch the Viking Spacecraft to Mars in 1975 and the Voyager deep-space probes in 1977. The Titan III uses Aerozine 50 and N_2O_4 propellants and two strap-on SRMs. Launch site for the commercial Titan III is Launch Complex 40 at Cape Canaveral AFB. The commercial Titan III is manufactured by Martin Marietta.

TITAN IV



Height (ft)	204.0 - Centaur, 174.0 ft - IUS
Weight (lbs)	1,900,000 - Centaur, 1,800,000 lbs - IUS
Liftoff Thrust (lbs)	3,566,000
Stage II	
Height (ft)	32.6
Diameter (ft)	10.0
Thrust (lbs)	104,000
Stage I	2
Height (ft)	86.5
Diameter (ft)	10.0
Thrust (lbs)	546,000
Solid Rocket Motors	2
Height (ft)	112.4
Diameter (ft)	10.5
Thrust (lbs)	1,783,000

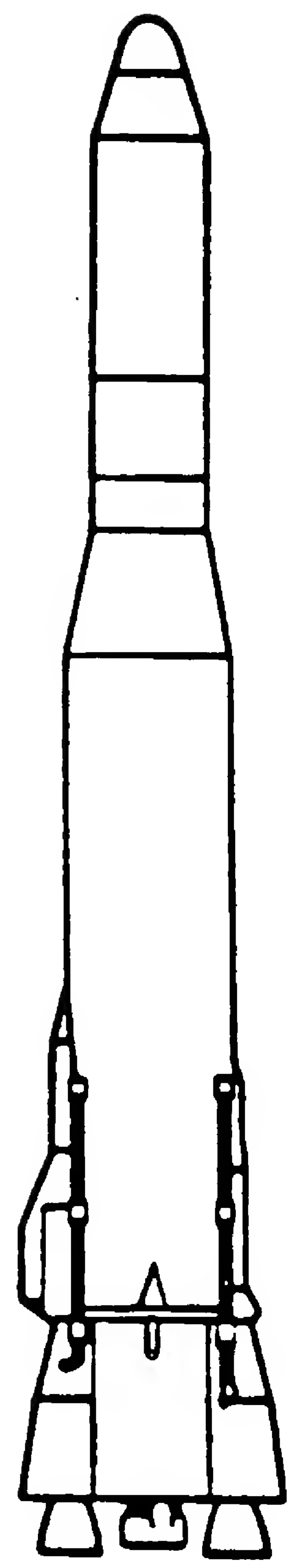
Payloads: DSP, Milstar, Other

GEO (lbs)	10,000
	12,500*
100NM Polar (lbs)	32,000**
100NM Due East (lbs)	39,000**

*With upgraded SRMs
**Upgraded SRM figures unavailable

The Titan IV, previously called the Titan 34D7/Complementary Expendable Launch Vehicle (CELV), is the newest and largest unmanned space launch vehicle developed by Air Force Systems Command (AFSC). The vehicle is designed to carry payloads equivalent in size and weight to those carried on the Shuttle. Modifications to the Titan IV include an improved Inertial Measurement Unit (IMU), enhanced electronics, and 7-segment SRMs vice the 34D's 5.5-segments. Upgraded SRMs, available in 1990, will be lighter and more powerful, using graphite epoxy casings instead of steel. These new SRMs will increase the Titan IV's Geosynchronous Earth Orbit (GEO) capability to 12,500 pounds. The Air Force has procured 23 Titan IV vehicles and is in the process of procuring an additional 20.

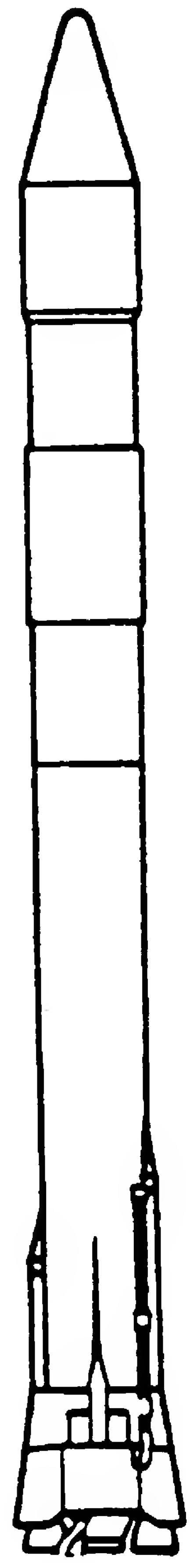
ATLAS E



Height (ft)	98.0
Weight (lbs)	266,000
Liftoff Thrust (lbs)	393,000
Booster and Sustainer Sections	
Height (ft)	67.3
Diameter (ft)	10.1
Thrust	
Sustainer Thrust (lbs)	60,000
Main Engine	
Thrust (lbs)	393,000
Payload: DMSP, NOAA	
100NM Polar (lbs)	1,750
100NM Due East (lbs)	3,100

Atlas space boosters were originally built as Intercontinental Ballistic Missiles (ICBMs) in the mid-l95Os. The Atlas was first used as a space launch vehicle in 1958. Today, the active boosters of the Atlas family are the E and Centaur models. The two vehicles are the same, except for their upper stage, the inertial guidance system, and main engines. The E model uses the NA-3 main engines, while the Atlas Centaur uses the NA-7. Atlas launch vehicles are propelled by a cluster of three liquid propellant main engines (two boosters and one sustainer engine). The manufacturer of the Atlas vehicles is General Dynamics.

ATLAS CENTAUR SPACE LAUNCH VEHICLE

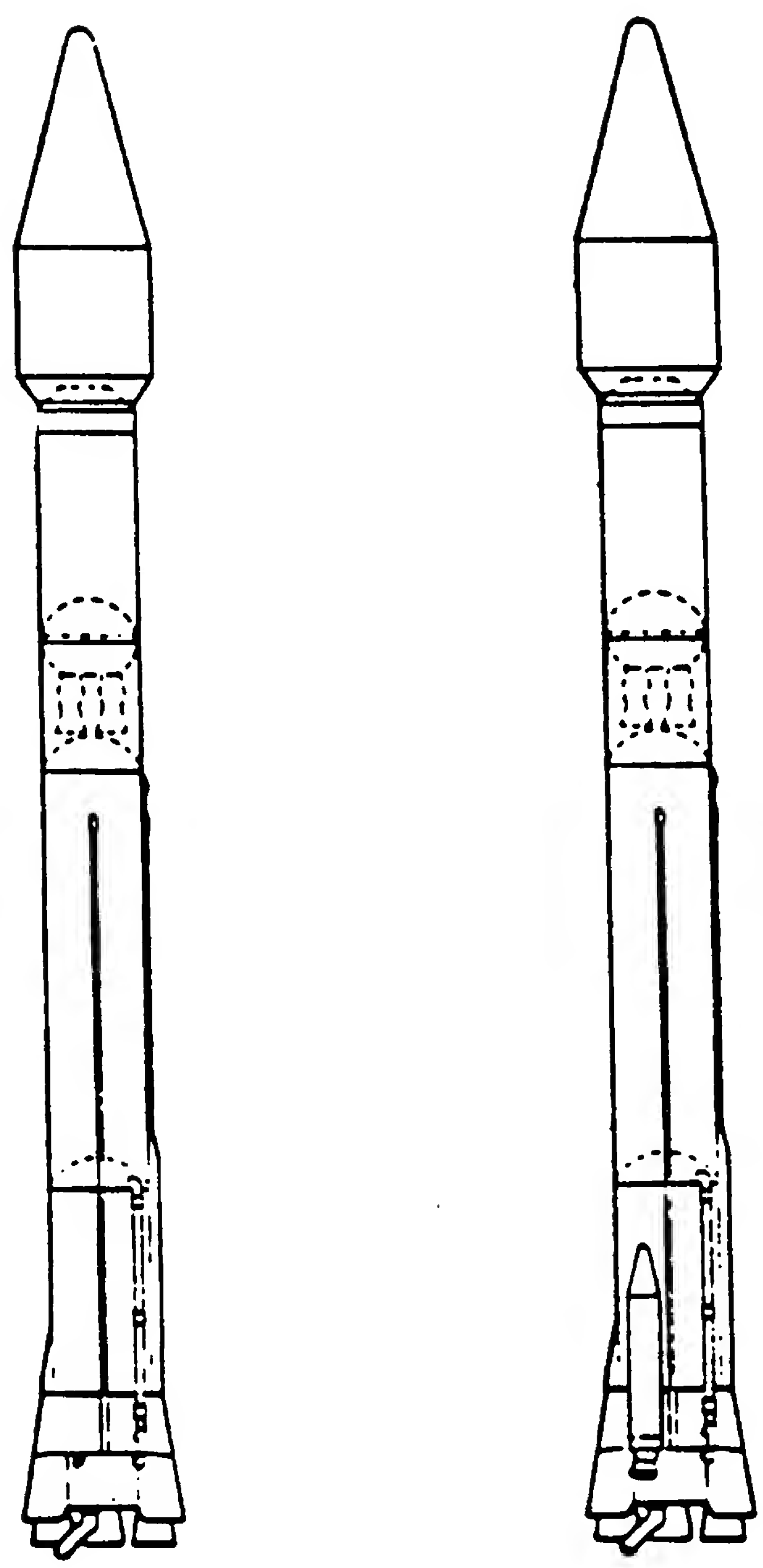


Height (ft)	131.0
Weight (lbs)	360,000
Liftoff Thrust (lbs)	437,000
Booster and Sustainer Sections	
Height (ft)	72.6
Diameter (ft)	10.0
Main Engine Thrust (lbs)	437,000
Sustainer Thrust (lbs)	60,000
Payloads: FLTSATCOM	
GEO (lbs)	2,650*
100NM Due East (lbs)	12,300
Centaur Stage	
Thrust (lbs)	60,000

*Requires Apogee Kick Motor

The Atlas Centaur was developed to provide launch services for geostationary payloads and heavy LEO payloads. The Atlas Centaur is equipped with more powerful main engines than other Atlas vehicles. The Centaur stage provides an additional 60,000 pounds of thrust.

ATLAS IIA AND ATLAS IIAS



	with medium fairing	with large fairing
Height (ft)	150	156
Weight (Atlas 11A) (lbs)	412,900	413,800
Thrust (Atlas IIA) (lbs)		509,000
(Atlas IIAS) (lbs)		613,300
Stage II (Centaur)		
Height (ft)		33.0
Diameter (ft)		10.0
Thrust (lbs)		40,500
Stage I (Atlas)		
Height (ft)		82.0
Diameter (ft)		10.0
Thrust (lbs) booster engines		408,000
(Sustainer engine)		60,500
(Atlas IIAS only) Solid Rocket Motors		
Height (ft)		TBD
Diameter (ft)		TBD
Thrust (lbs)		104,300 (Total)

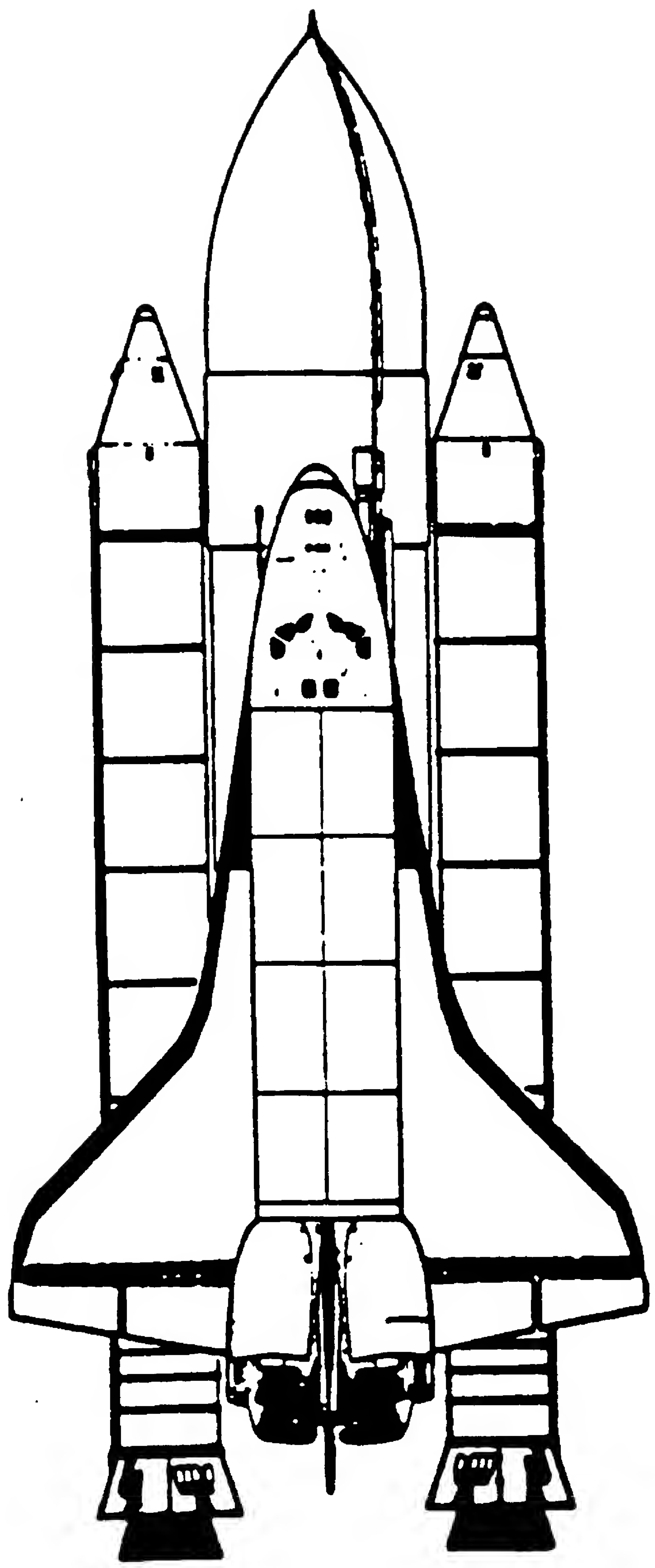
Payloads: Commercial communications satellites and other payloads, and government payloads

		Medium Fairing (lbs)	Large Fairing (lbs)
GTO	(Atlas IIA)	6,400	6,200
	(Atlas IIAS)	6,950	6,750
LEO	(Atlas IIA)	15,700	15,250
	(Atlas IIAS)	15,850	16,400
Planetary	(Atlas IIA)	4,620	4,370
	(Atlas IIAS	5,220	4,970

The Atlas IIA and IIAS are the same except that the Atlas IIAS has CTPB-fueled SRMs to provide greater lift capability. Both are derived from the Atlas II with an improved Centaur stage for providing greater thrust. The Centaur stage uses LH_2 and LO_2 and the Atlas stage uses LO_2 and RP-I for propellant.

The projected launch site is Cape Canaveral. Availability dates are 1991 for the Atlas IIA and 1992 for the Atlas IIAS.

SPACE SHUTTLE



Height (ft)	184.2
Weight (lbs)	4,400,000
Liftoff Thrust (lbs)	6,800,000
Orbiter	
Length (ft)	121.0
Width (ft)	79.0
Cargo Bay (length) (ft)	60.0
(diameter) (ft)	15.0
Weight (lbs)	150,000
Cross Range-Nautical Miles	1,100nm
Thrust (3 main engines)	470,000 each
(2 OMS engines	6,000 lbs each
External Tank	
Height (ft)	154.4
Diameter (ft)	27.8
Weight (lbs)	1,649,600 (full) 71,000 (inert)

(Advanced) Solid Rocket Boosters

Height (ft)	149.1
Diameter (ft)	12.2
Thrust (lbs)	2,712,000 each

Payloads: GPS, DSP, Research and Development, LEASAT, TDRSS, and others

Geosynchronous Earth Orbit (GEO) with Inertial Upper Stage (IUS) 5,250 lbs

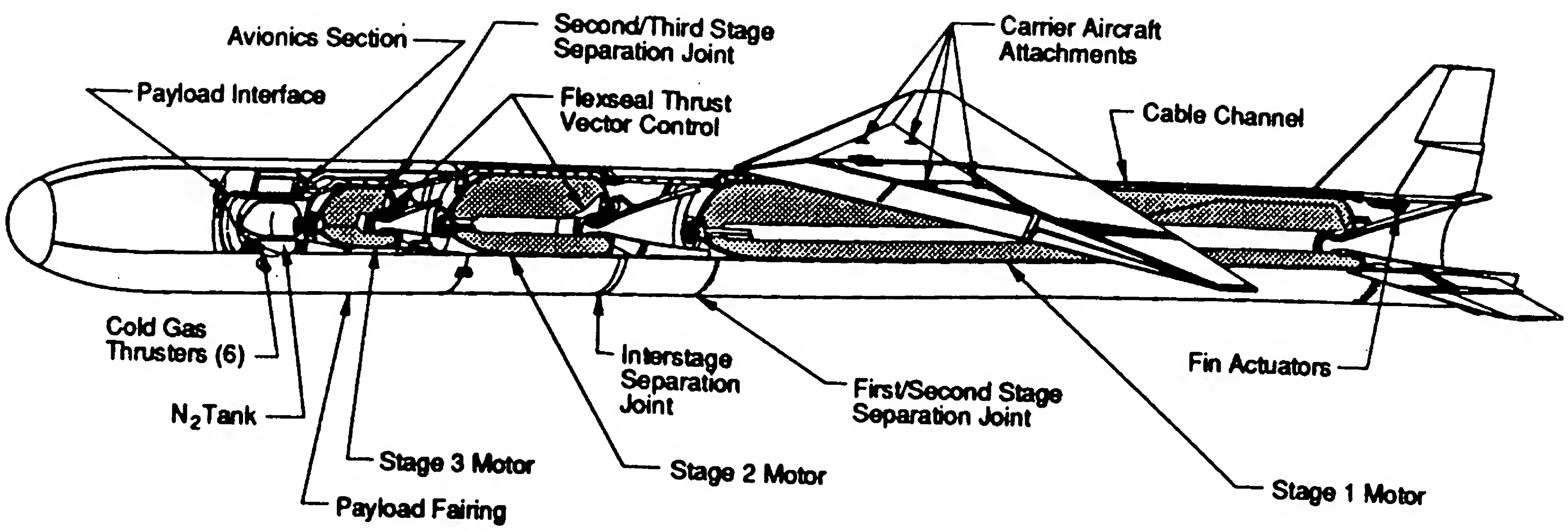
Geosynchronous Transfer Orbit (GTO) with Payload Assist Module (PAM) D 2,750 lbs and with PAM DII 4,160 LBS

110nm Polar (lbs)	29,600
110nm Due East (lbs)	50,200

The typical mission length of the Space Shuttle is 7 days. Crew size varies between four and seven people per mission. The Space Shuttle system consists of the Orbiter, two reusable Solid Rocket Boosters (SRBs), and the External Tank. The launch site for the Shuttle is Cape Canaveral AFB and the landing site is located at Edwards AFB. Typical altitude of the Shuttle Orbiter is 135-320 nautical miles (NM).

Manufacturers of Shuttle components include Rockwell for the Orbiter, Morton-Thiokol for the SRBs, and Martin Marietta for the external tank.

PEGASUS



<u>Launch Vehicle Characteristics</u>

- 41,000 lb Gross Weight
- Up to 1,000 lb Payload
- 50 ft Long, 50 in Diameter
- All Graphite-Composite Structure
- 3-Stage Solid Rocket Motors (Class 1.3 Propellant)
- 3-Axis Inertial Attitude Control (Advanced Electronics)
- Winged Vehicle for Lifting Ascent

<u>Carrier Aircraft Alternatives</u>

- NASA NB-52B (Development Flights)
- SAC B-52 G or H
- SAC KC-10
- Commercial Transport (L-1011, 747)

The Pegasus is a small air launched satellite booster. Pegasus is currently being examined by the DARPA for possible use with tactical reconnaissance, tactical communications and control, and overhead imagery payloads. Advantages of the Pegasus launch vehicle are the mobility of its launch platform and quick deployability (within 72 hours of call-up). It will be used to boost payloads to LEO.

The Advanced Launch System

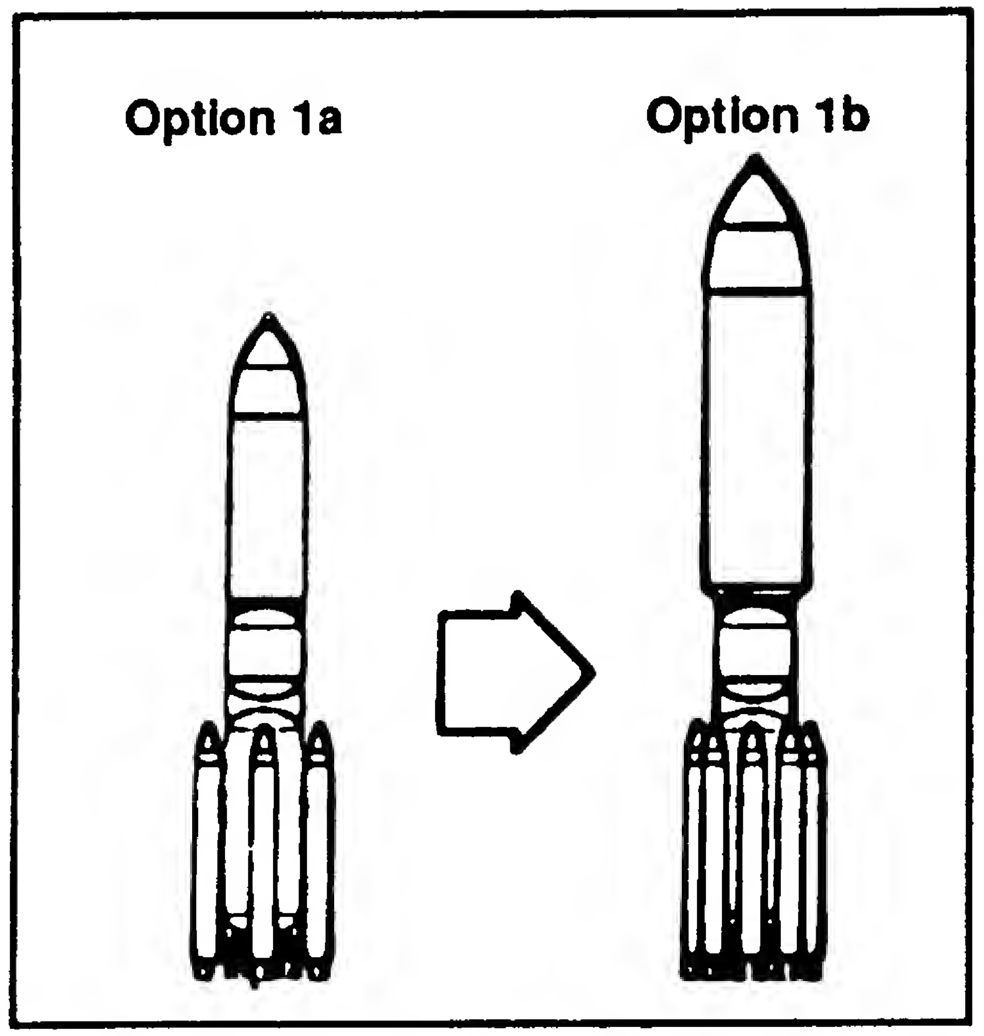
The Advanced Launch System (ALS) is a family of SLVs to support launches of 1,000 to 160,000 lbs to orbit for various programs. The fundamental program purpose is to employ technological advances to enhance responsiveness and significantly reduce launch costs. Additionally, current and projected programs can benefit from ALS cost reductions, increased capacity, and applications of advanced technology to mature SLV design. The ALS payloads are envisioned as those requiring heavy lift capacity such as Strategic Defense System payloads, Space Station components, interplanetary missions, and existing USCINCSPACE mission payloads.

First proposed in 1987, the ALS is currently in the Technology Demonstration and Evaluation phase which will last from 1988 to 1990. Three contracts have been awarded for this phase: Boeing, General Dynamics, and the Martin Marietta-McDonnell Douglas team. The following pages illustrate the contractors' proposed designs.

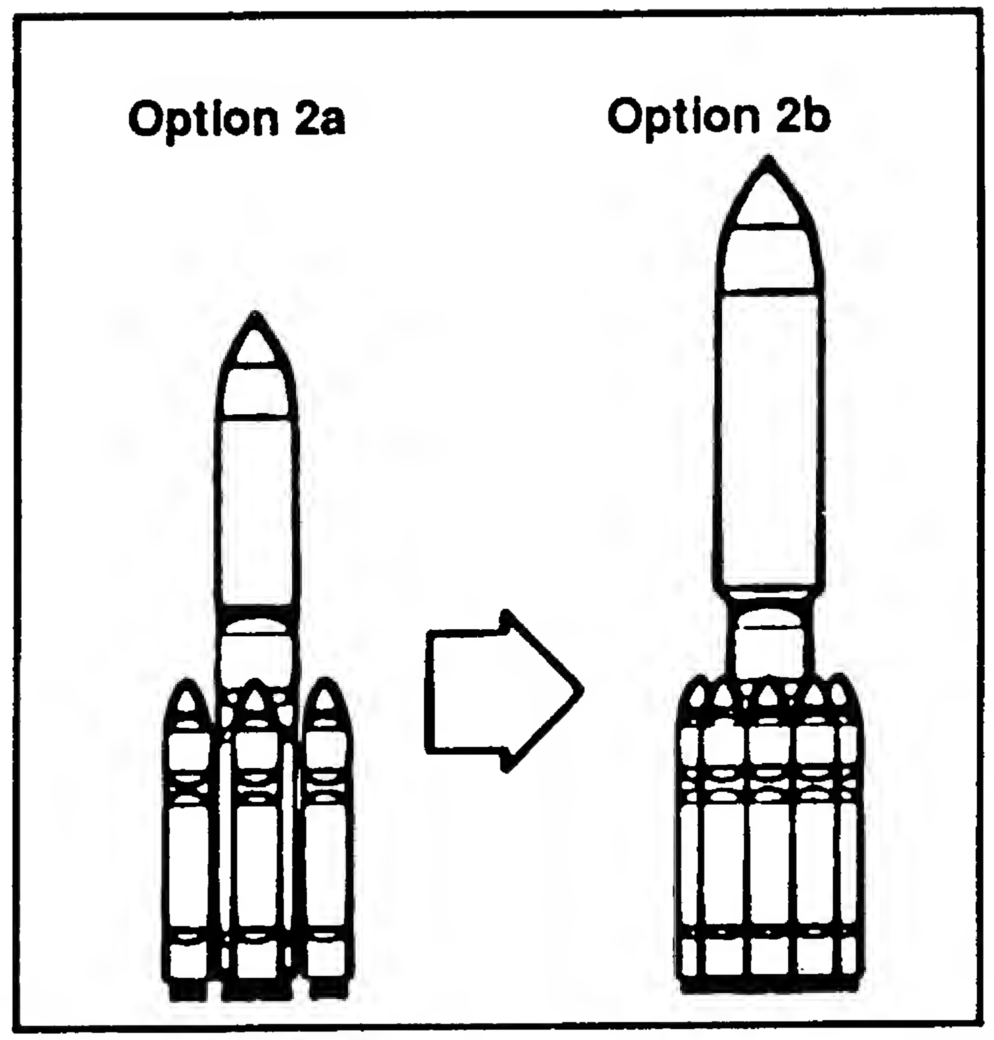
Specific requirements for the ALS include the following: Deliver 4,000 to 150,000 lbs to LEO; 5,000 to 15,000 lbs to GEO; and 1,000 to 160,000 lbs to polar orbit. Aggregate payload mass will be 1,000,000 lbs per year by 1998 (at the initial operational Capability), and will grow linearly to 5,000,000 lbs per year by the year 2000. Launch rate is projected to be 35 launches per year with the capability to launch any assigned payload within 30 days of notification. The ALS will be required to meet launch-on-need and surge rate launch schedules. Initial launch capability for the ALS is projected to be 1996.

Generic vehicle characteristics of the ALS will include the use of LO_2/LH_2 (cryogenic) propellant, the use of solid and/or liquid rocket boosters (SRBs and LRBs), and potential use of reusable vehicle configurations.

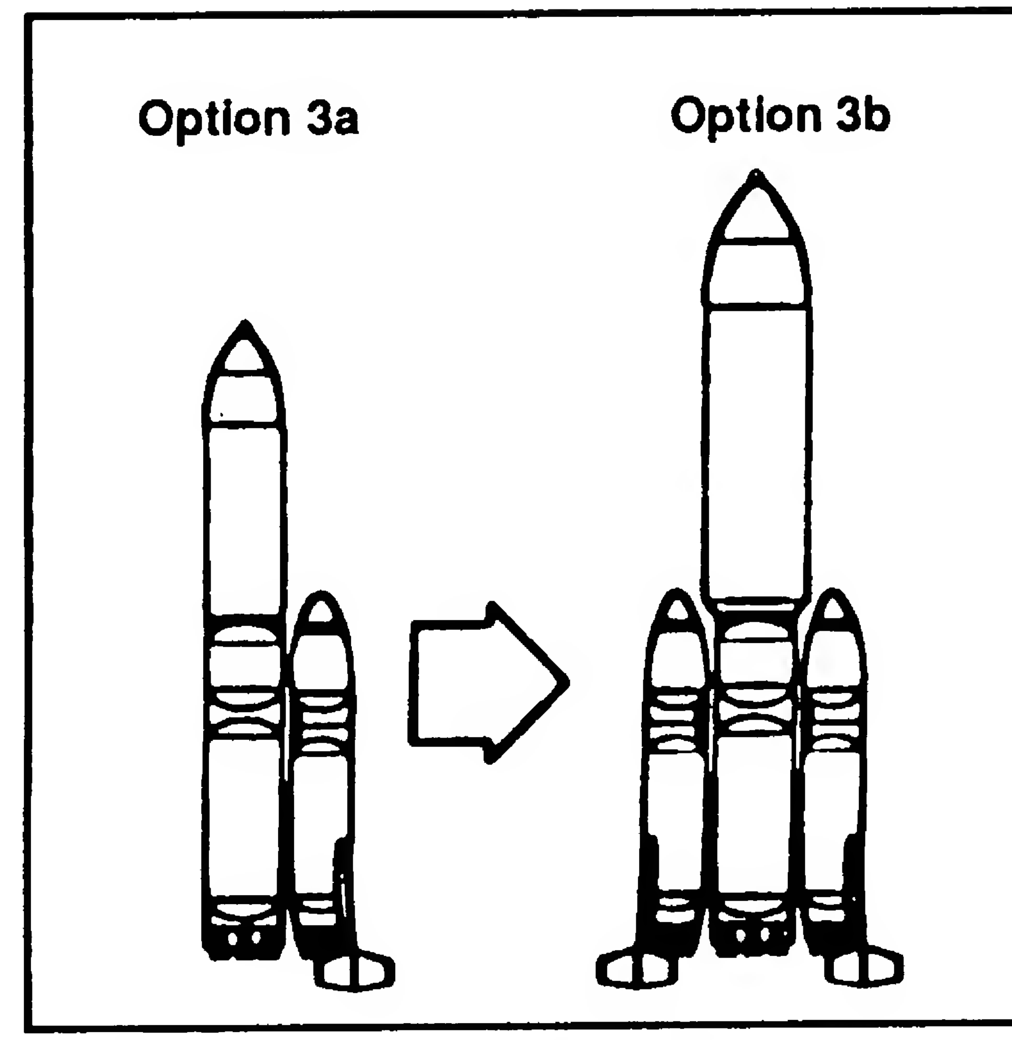
ALS REFERENCE VEHICLE CONFIGURATION SUMMARY



- Expendable Liquid Core
- 4/8 Expendable Solid Boosters



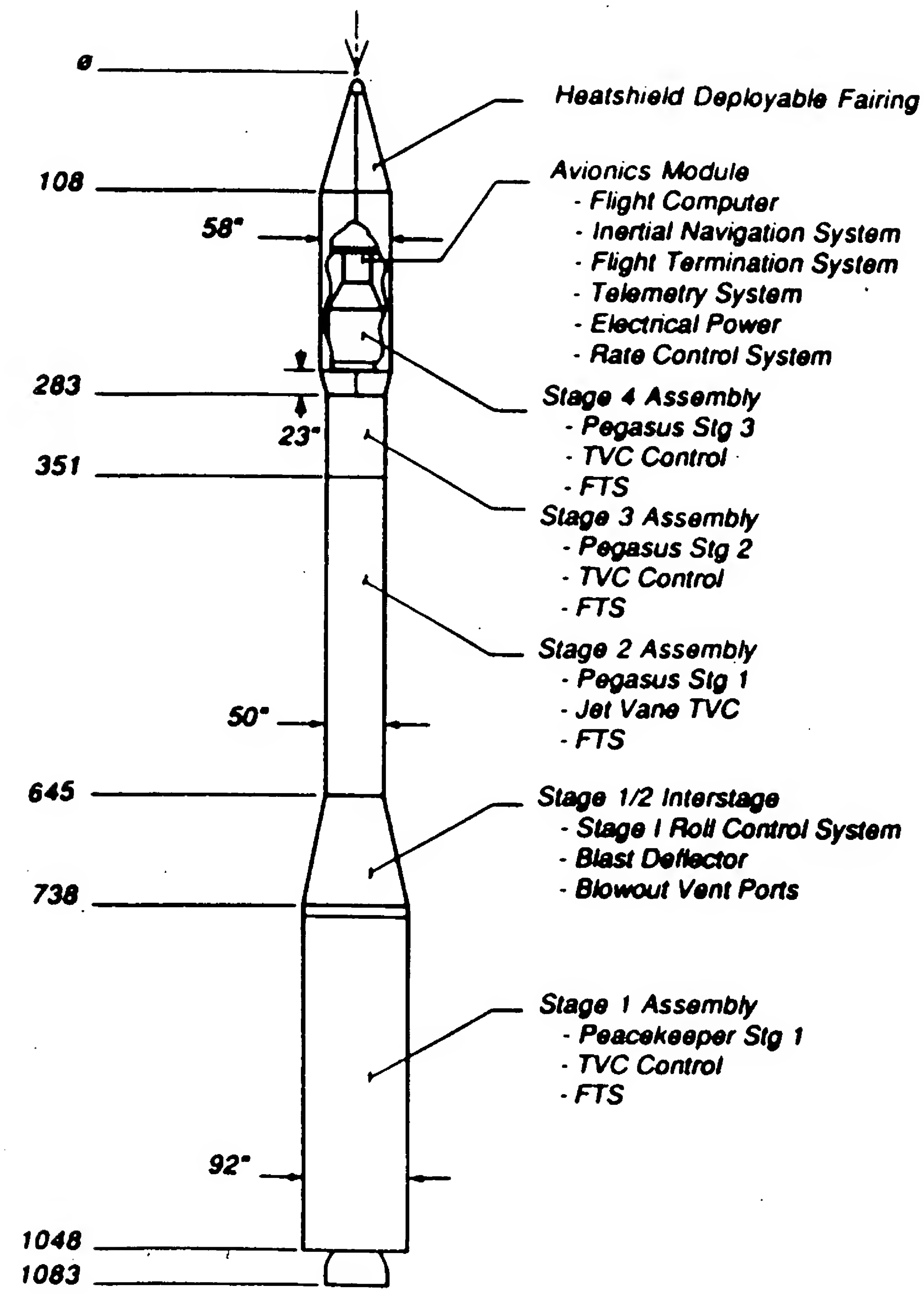
- Expendable Liquid Core
- 4/8 Expendable Liquid Boosters



- Expendable Liquid Core
- 1/2 Reusable Liquid Booster(s)

The three vehicle configuration options are optimized for the normal mission model, with growth configurations (160 Klb Polar) sized for the expanded mission model. All options include an expendable liquid core stage, which is consistent between the normal and growth configurations, excluding the expanded fairing. The core stage is optimized for each option, and therefore is different for each option. Booster options being studied include expendable solids, expendable liquids, and resusable (flyback) liquids. In all cases, the growth option is achieved by increasing the number of boosters from the normal mission configuration, with no increase in the size of the core stage. A 45' diameter fairing is added to accommodate the larger expanded mission model payloads in all growth options.

STANDARD SMALL LAUNCH VEHICLE (SSLV)



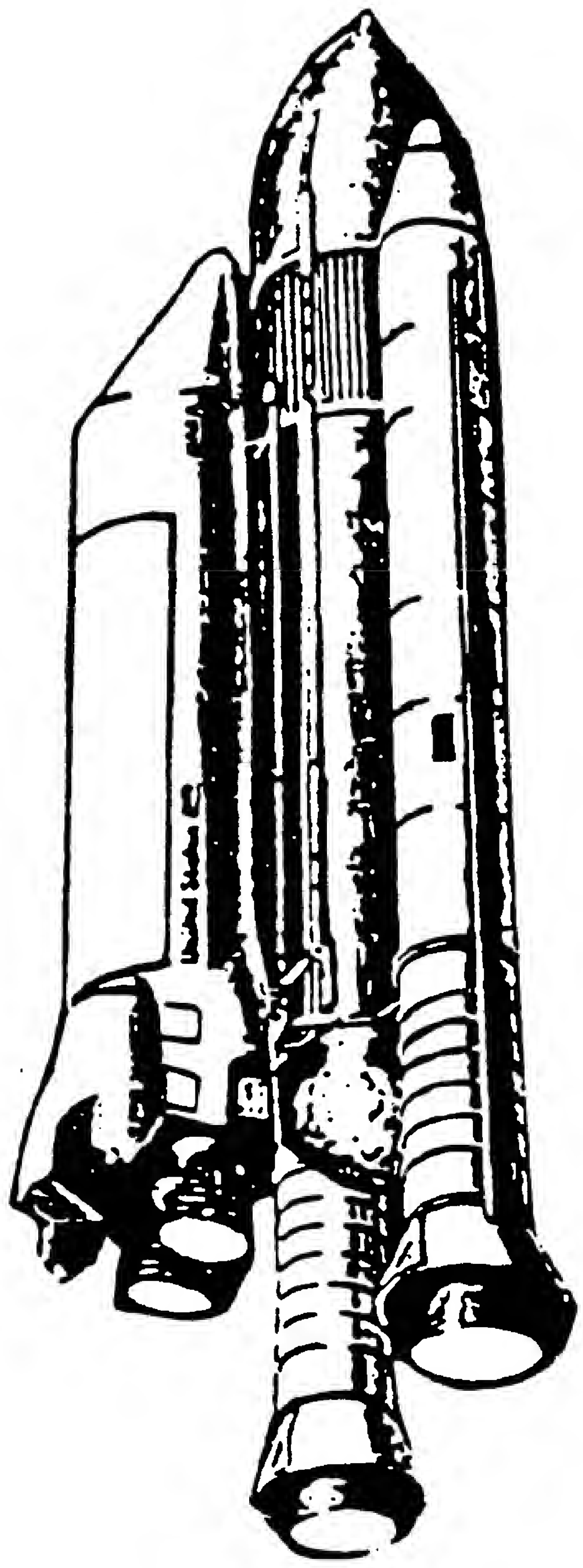
SSLV CAPABILITIES

- Performance (Design Reference Missions)
  - 830 lb ETR to Geosynchronous Transfer Orbit
  - 2300 lb WTR to 400 nmi Circular 90^{o} Inclination
  - 3300 lb ETR to 250 nmi Circular 28.5^{o} Inclination
  - 720 lb ETR to 260 x 22,000 nmi 24 hr Molniya Inclination
  - 925 lb ETR Earth Escape Transfer Mass for C_3 = 12 km_2/sec_2
- Overall Length 87.75 ft (26.78m)
- Gross Lift-Off Weight 180,000 lb (81,648 kg)
- Modified Pegasus Avionics System
- Four Solid Rocket Motor Stages (Class 1.3 Propellants)

Stage 1	Peacekeeper Stage 1
Stage 2	Pegasus Stage 1
Stage 3	Pegasus Stage 2
Stage 4	Pegasus Stage 3

The SSLV is a DARPA program to develop a new launch vehicle for satellites in the 700 to 3,300 pound range. The initial demonstration contract between DARPA and Orbital Sciences Corporation (OSC) was signed in July 1989 with a demonstration launch scheduled for the first-half of 1991. The SSLV is a four-stage, initertially-guided, 3-axis stabilized, solid propellant launch vehicle whose configuration is based on the air launched Pegasus and other launch systems such as Peacekeeper.

SHUTTLE-C/HEAVY-LIFT LAUNCH VEHICLE



Height (ft)	184.2
Weight (lbs)	4,400,000
Liftoff Thrust (lbs)	6,710,000 (3 SSMEs)
Unmanned Cargo Pod	
Height (ft)	122.2
Diameter (ft)	TBD
Thrust (lbs) (3 SSMEs*)	1,410,000
Thrust (lbs) (2 SSMEs)	940,000
External Tank	
Height (ft)	154.4
Diameter (ft)	27.8
Weight (lbs)	1,649,600 (full) 71,000 (inert)
Solid Rocket Boosters	
Height (ft)	149.1
Diameter (ft)	2,650,000 each
Total	5,300,000

Payloads: Space Station, Components, Planetary probes, scientific and research missions

110nm LEO (lbs)	178,000 to 190,000
220nm Polar (lbs)	84,000 to 112,000

*SSME = Space Shuttle Main Engine

The Shuttle-C is basically the same design as the manned Shuttle with an unmanned cargo pod in place of the Orbiter. The Shuttle-C will lift more cargo than the Orbiter and therefore will be useful as a heavy-lift vehicle, especially for carrying payloads necessary for Space Station assembly. Currently under development, the Shuttle-C, also known as the Heavy-Lift Launch Vehicle, enables use of solid rocket motors, presently in storage, of the same design as those used by Challenger. With first launch planned in 1993-94, the Shuttle-C will use the same facility at Kennedy Space Center as the manned Shuttle (Launch Complex 39).

Propellant for the Shuttle-C cargo pod engines will be LO_2 and LH_2 stored in the external tank. Two solid rocket motors will be strapped to the external tank, Proposed missions for the Shuttle-C (in addition to launch of Space Station components) include Mars Rover/Sample Return, Large Deployable Reflector, Cassini (Saturn Orbiter/Titan Probe), Comet Nucleus Sample Return, Comet Rendezvous Asteroid Flyby, and Saturn Flyby/Probe.

The Shuttle-C will use 2 or 3 Space Shuttle main engines for the cargo pod's engines.

UPPER STAGES

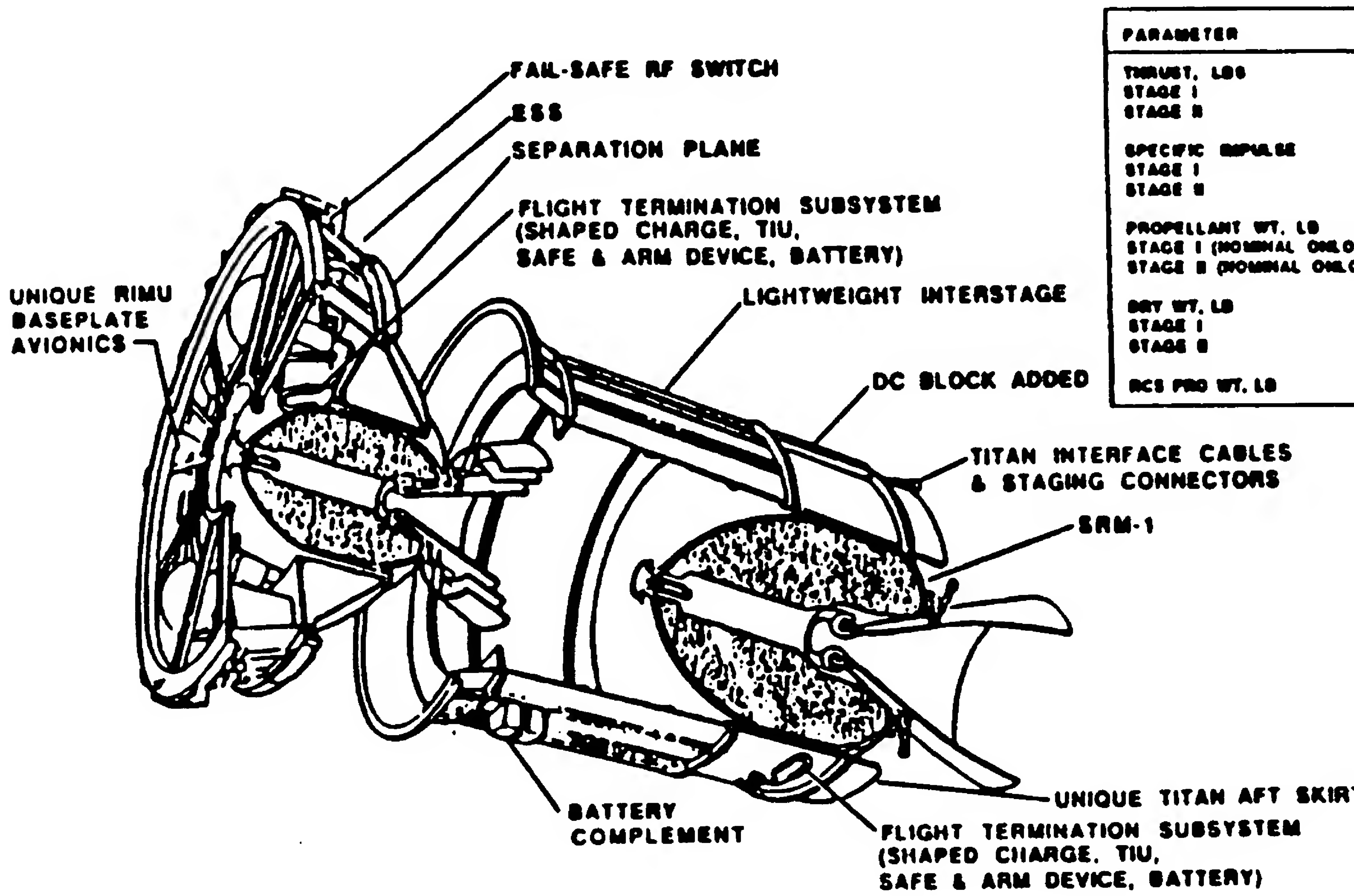
Inertial Upper Stage

The Inertial Upper Stage (IUS) vehicle is designed to meet DoD and NASA operational space needs in the 1980s and beyond. The IUS is a flexible two-stage system capable of transporting a variety of DoD and NASA satellites. It is compatible with the Shuttle, the Titan 34D, and the Titan IV. On Space Transportation System (STS) missions, the aft skirt of the first stage provides the mechanical interface to the cradle mounted in the cargo bay. The IUS features two solid propellant motors as its main propulsion unit, and liquid propellant reaction control system engines for minor adjustments and vehicle control. As a result of its unique guidance feedback system and redundant avionics, it is Capable of reaching the desired orbit with a high degree of accuracy and reliability. Current figures are:
Accuracy

GEO position	+ 92 (NM)
GEO Velocity	+ 78 (FT/S)
GEO Inclination	+ 0.12 (DEG)

The IUS is 17 feet long and 9.5 feet in diameter. Its maximum payload weight is 5,250 pounds to GEO aboard Titan IV. The IUS was initially launched in October 1982. The second launch in April 1983 was unsuccessful due to a failure in the IUS solid propellant motor. However, the payload, 8 Tracking and Data Relay Satellite (TDRS), successfully achieved the desired orbit by using its on-board fuel supply and thruster motors. Following an extensive investigation and recovery program, the IUS again proved successful in January 1985.

PARAMETER	VALUE
THRUST, LBS	
STAGE I	41,576
STAGE II	16,742
SPECIFIC IMPULSE	
STAGE I	292.30
STAGE II	301.22
PROPELLANT WT, LB	
STAGE I (NOMINAL ONLOADS)	21,404
STAGE II (NOMINAL ONLOADS)	6,060
DRY WT, LB	
STAGE I	2,403
STAGE II	2,216
RCS PRO WT, LB	245



APPENDIX E

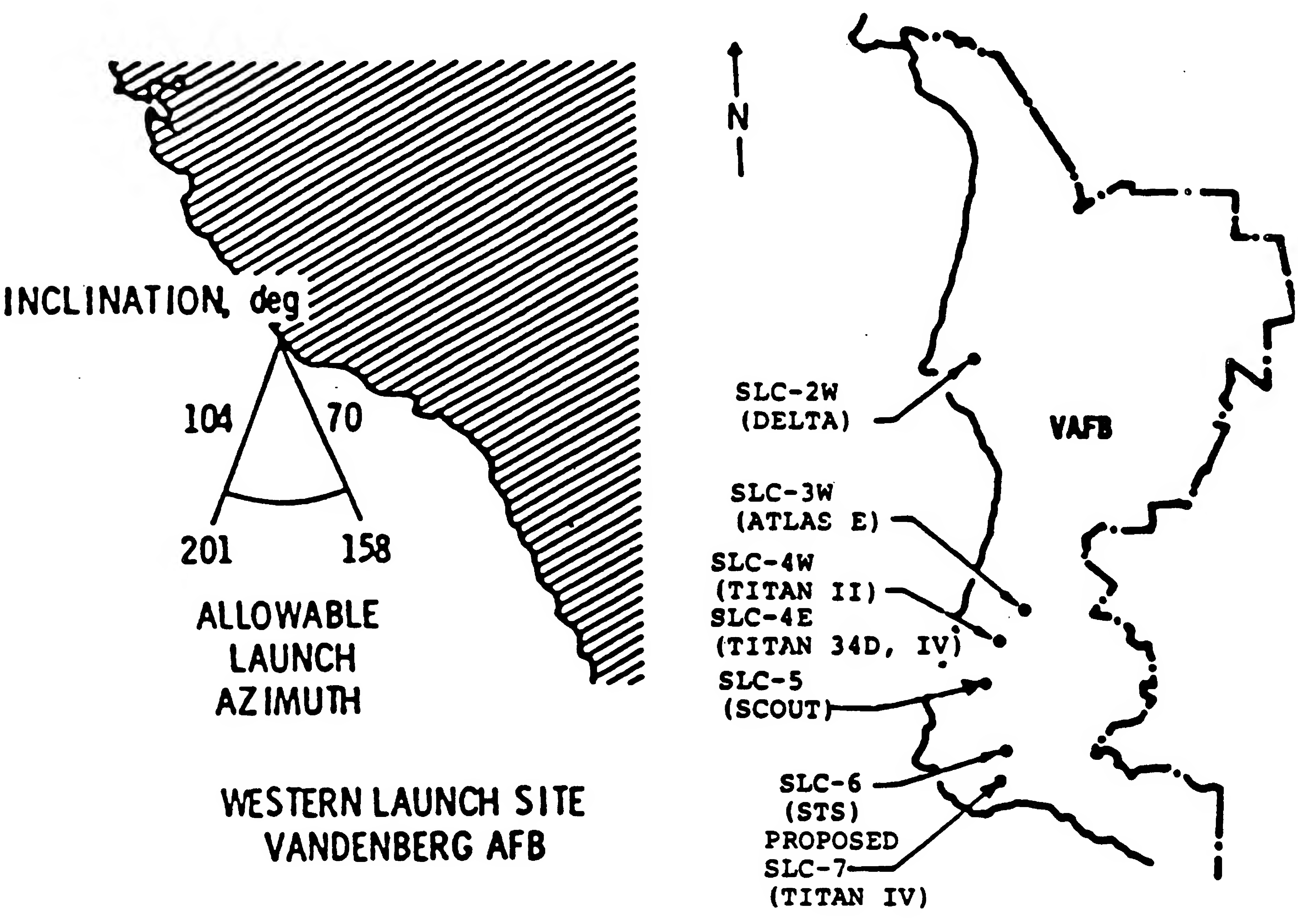
LAUNCH FACILITY CHARACTERISTICS

WORLDWIDE SPACE LAUNCH SITES

1. Vandenberg AFB, CA - USA
2. Wallops Island, VA - USA
3. Cape Canaveral AFB and Kennedy Space Center, FL - USA
4. Kourou, French Guiana - France
5. San Marco, Kenya - Italy
6. Plesetsk - USSR
7. Kapustin Yar - USSR
8. Tyuratam (Baikonur Cosmodrome) - USSR
9. Sriharikota - India
10. Jiuquan (Shuang Cheng Tzu) - PRC
11. Taiyuan - PRC
12 Xichang - PRC
13 Kagoshima - Japan
14 Tanegashima - Japan

Vandenberg Air Force Base

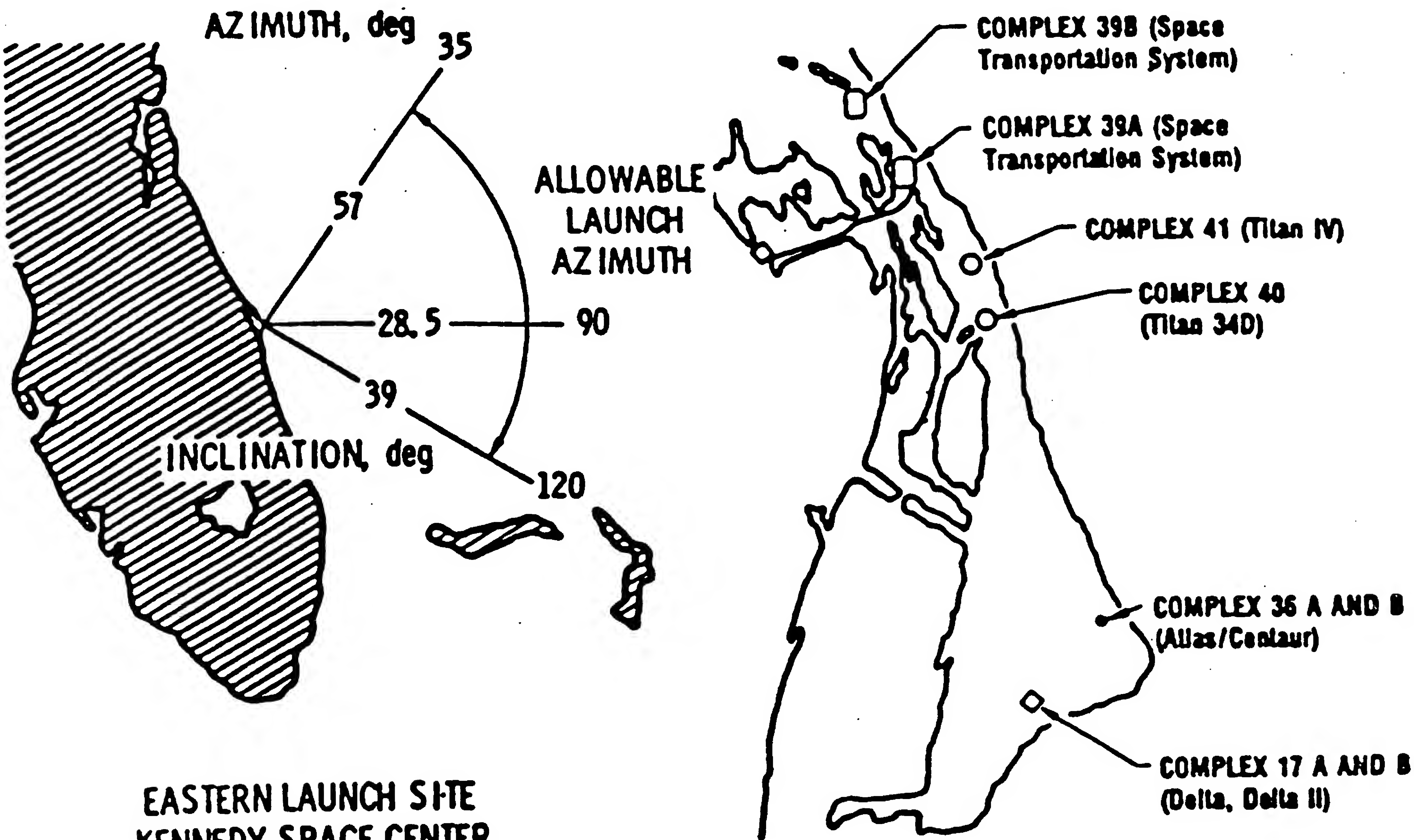
Vandenberg Air Force Base (VAFB) developed out of the need for an operational training facility for IRBM and ICBM crews. The first launch from VAFB was a Thor launched in 1958. VAFB has launch facilities for the Scout, Delta, Atlas, and Titan Expendable Launch Vehicles (ELVs), in addition to a mothballed facility for shuttle launches. Currently, Space Launch Complex (SLC)-7 is under construction for the Titan IV. VAFB launch azimuth, inclination coverage and launch facilities are shown below.



WESTERN LAUNCH SITE
VANDENBERG AFB

Kennedy Space Center and Cape Canaveral Air Force Base

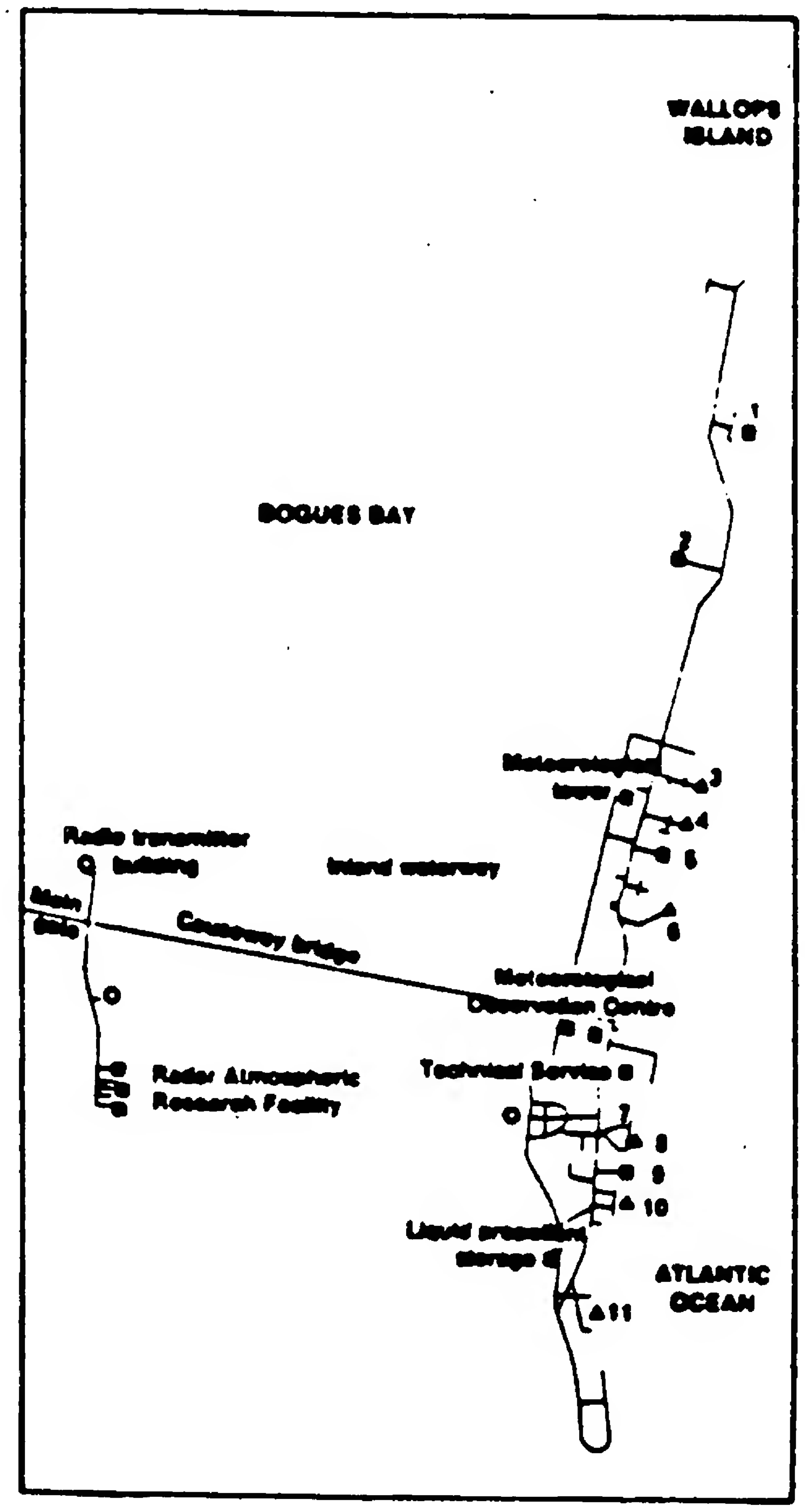
Cape Canaveral was established in 1946 in response to the Joint Chiefs of Staff request for a long range missile proving ground. The Cape was chosen because it features large areas of nearby ocean. However due to nearby land masses and population centers, the Cape is limited to orbital inclinations of 39-57 degrees. Allowable Kennedy Space Center (RSC) and Cape Canaveral Air Force Base (CCAFB) ,launch azimuth and inclination coverage and launch facilities are CCAFB has facilities for launch of the Scout, Delta, Atlas, and Titan ELVs. Nearby KSC has facilities for Shuttle launch and recovery.



EASTERN LAUNCH SITE
KENNEDY SPACE CENTER

Wallops Flight Facility

Wallops Flight Facility was developed following World War II. Its use for sounding rockets began in 1945. By the end of the 1980, over 11,000 sounding rockets had been launched from Wallops Flight Facility. The first orbital launch occurred in 1960 using the Scout launch vehicle. Since that date, 20 Scout Vehicles have been orbited from Launch Area-3. Scout launches represent approximately two percent of the total number of US orbital launches. The Scout facility at Wallops Flight Facility also served as a training site for Italian launch crews, who launch the Scout vehicle from San Marco Platform off the coast of Kenya.



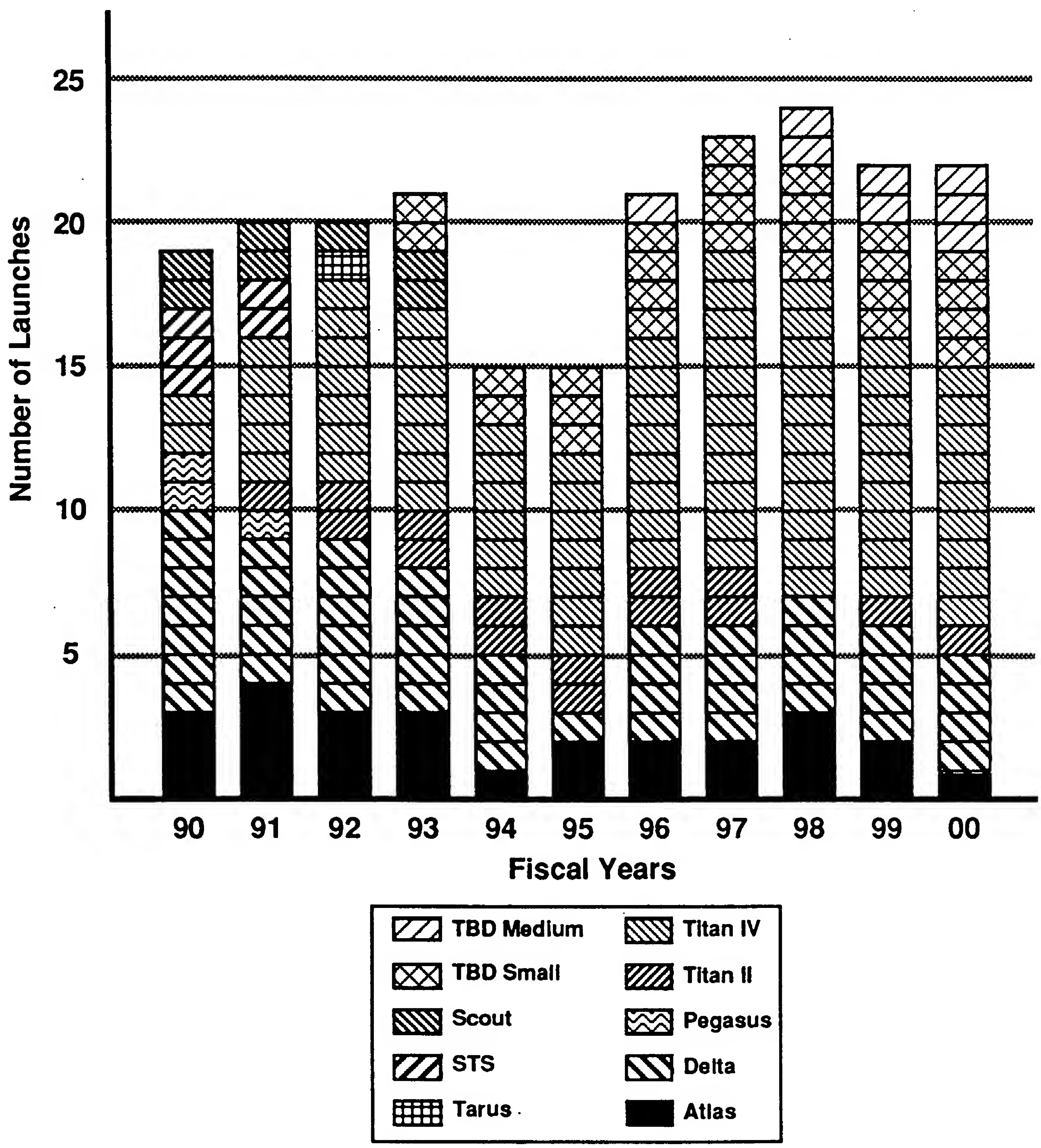
Wallops Island
1 Dynamic balance facility
2 Payload checkout and assembly area
3 Launch area No 5
4 Launch area No 4
5 Blockhouse No 3
6 Launch area No 3
7 250ft (76 2m) meteorological tower
8 Launch area No 2 and blockhouse No 2
9 Assembly shop No 1
10 Launch area No 1
11 Launch area No 0

Road
Base facility
Launch area

APPENDIX F

NATIONAL SECURITY LAUNCH REQUIREMENTS

National Security Launch Vehicle Requirements



APPENDIX G

INTERIM REPORT TO CONGRESS

Interim Response

on

DoD Use of the Shuttle in the Mid-to-Late 1990s

The National Defense Authorization Act for FY 1989 Senate Report directed that the Secretary of Defense request that the Defense Science Board (DSB) review space launch requirements in the mid-to-late 1990s to determine whether the Shuttle should be included in the array of space launch vehicles for the DoD. In response to this request, the DSB has begun a broad look at national security launch strategy, scheduled to be completed in the late summer of 1989. This is too late to provide information for the ongoing deliberations of the Congress on the FY 1990 budget, and this interim response to the request is provided by DoD to assist in that process.

This interim response addresses the issues requested in the Senate Report. It does not replace the more comprehensive report that will result from the DSB Summer Study. Although the DSB study group has reviewed this response, the DSB has the responsibility to provide an independent recommendation based on their in-depth study. The DSB Report will be submitted to the Committees on Armed Services of the Senate and House of Representatives following the conclusion of their study and review by the Secretary of Defense.

Summary of Launch Recovery Activities

The Space Launch Recovery, consisting of major efforts by NASA to return the Space Transportation System to safe operations and by the DoD to reestablish a robust expendable launch vehicle capability, began immediately following the Challenger and Titan 34D accidents in early 1986. Both aspects of the recovery have been successful, as evidenced by flights of the Shuttle and the Atlas E, Titan II, Titan 34D, Delta, and Delta II. Although the systems initiated under the recovery program will continue as long as we fly the current generation of launch vehicles, by 1990 we will have crossed the threshold from "recovery" to "sustained operations" of a national mixed fleet of space launch vehicles.

Within the DoD launch recovery program, several key milestones have passed, and others are scheduled over the next three years. The first launch of the Delta II, carrying the first production Global Positioning System satellite, occurred in February 1989, less than 26 months after contract award for this

new class of medium launch vehicle. Initial Launch Capability for the nation's largest unmanned vehicle, the Titan IV, was achieved in February 1989. The actual first Titan IV launch has been rescheduled to accommodate other launch activities on the east coast.

Following the FY 1989 launch activity from the Titan facilities at Cape Canaveral Air Force Station (CCAFS), Space Launch Complex (SLC)-41 will undergo modifications to support the Titan IV with the Centaur upper stage. SLC-40 is also scheduled to be modified from its present Titan 34D/III configuration to be able to support the Titan IV/Centaur and the commercial Titan 34K. The SLC-40 modifications and a new Solid Motor Assembly Building capable of handling the new Titan IV Solid Rocket Motor Upgrade (SRMU) and providing essential expansion of the launch capacity at CCAFS are included in the FY 1990 budget. The availability of the first SRMU may be delayed by six months as a result of the recent fire at the propellant mixing facility at Magna, UT. An option for six additional sets of the present Solid Rocket Motor was exercised last fall to ensure the manifest can be flown.

The Atlas II launch vehicle and modifications to SLC-36 and the Defense Satellite Communications Systems III satellites for launch with the Centaur upper stage continue toward a mid-1991 Initial Launch Capability. The Atlas II, a derivative of the proven Atlas Centaur, was selected following an intense competition for the DSCS missions and completes the family of medium launch vehicles required for east coast access to space through the mid-to-late 1990s.

On the west coast, modification of SLC-4 West for Titan II was completed and the first launch took place in September 1988, providing the capability to launch payloads such as the Defense Meteorological Satellite or NOAA Polar Weather Satellite from Vandenberg. Modification of SLC-4 East to accommodate the Titan IV began immediately after the last Titan 34D mission from that complex in November 1988. Most of the structural modules have been shipped, and the site is expected to achieve Initial Launch Capability (ILC) in mid-1990.

The question of whether to construct a new facility for Titan IV or modify the Shuttle facilities (SLC-6) for Titan IV use will be addressed later in this report. In accordance with congressional direction, the Shuttle facilities at Vandenberg AFB are being converted to "Mothball" status, and all assets that can be used in support of NASA or other DoD programs are being transferred. That process is nearly complete, and full Mothball status will be achieved by the end of FY 1989. A report on the content, schedule, and cost of the Mothball program was submitted to the Congress in July 1988. The Air Force estimates that as of that date it would require approximately $1 billion and four to

six years to restore SLC-6 to flight status for manned Shuttle operations. Although the four-to-six-years lead time will probably be valid indefinitely, the cost estimate will increase over time as the configuration of the Shuttle facility at Kennedy Space Center continues to diverge from the pre-Challenger configuration that served as the baseline for the Vandenberg facility.

DoD Use of the Shuttle

The second flight of the Shuttle following the return to operations carried a DoD payload, and seven more dedicated DoD missions are scheduled through 1991. The DoD has credits for nine flights, and the last credit is expected to be used for R&D experiments, sharing the payload bay with NASA. Following the last dedicated mission, STS-46, the DoD does not plan to use the Shuttle for any further classified missions. Following that mission, DoD utilization of the Shuttle will be limited to R&D activities and SDI experiments.

The Air Force has advised NASA that the requirement for classified, or Controlled Mode, operations will end following STS-46. This decision, which will save $70 to $100 million per year, will limit the potential use of the Shuttle by the DoD to those payloads that can be launched in an unclassified environment. DoD policy requires that operational launches be classified except where specific waivers have been given; therefore, future use of the Shuttle will be limited to unclassified R&D flights and operational flights which require the unique attributes of the manned vehicle.

The DoD decisions on use of the Shuttle resulted from many factors, and were reviewed at some length during the Committee's work on the FY 1989 budget. In many cases it was necessary to move payloads from the Shuttle to ELVs in order to provide access to space in the shortest possible time and to ensure sufficient capacity was available for NASA to complete its highest priority science missions. For example, the GPS deployments that are being accommodated easily on the Delta II ELV would have taken up nearly 20 percent of the total Shuttle capacity between 1989 and 1992. DSCS, which will use the Atlas II, and the Defense Support Program, which will use the Titan IV, would have used another 10-15 percent. Other classified DoD payloads, now manifested on Titan IV, could have put the DoD requirement at over 50 percent of the anticipated Shuttle capacity.

The second major factor in the DoD decision was Shuttle performance. Decisions made after the Challenger accident to operate the Shuttle at 104 percent of rated thrust (vice 109 percent) and to retain steel cases for Solid Rocket Boosters (vice filament wound cases) reduced the capability of the Shuttle

to polar orbit to approximately 16,000 lb (vice the requirement for 32,000 lb). DoD payloads previously scheduled for launch from Vandenberg could not be carried to orbit. On the east coast, many of the payloads scheduled from Kennedy Space Center would suffer mission degradation in order to reduce payload weight or deployment altitude to stay within Shuttle limits. The third principal factor, also performance related, was the cancellation of the Centaur upper stage for the Shuttle. This decision by NASA forced all DoD payloads that exceed the capabilities of the Shuttle/Inertial Upper Stage (approximately 5,000 lb to geostationary orbit) to move from the Shuttle to the Titan IV.

The fourth factor was cost. The direct launch cost to the DoD for flying on the Shuttle compared to flying on a Titan IV is approximately the same. The cost for flying equivalent capacity on either the Delta II (1/3 payload bay) or Atlas II (1/2 payload bay) favors the ELV. These comparisons are valid even if only the actual launch costs are included: vehicle and launch services for ELVs versus direct reimbursement to NASA for the Shuttle based on $115 million (FY 86 $). The hidden Shuttle costs to DoD that can be avoided, including Controlled Mode and nearly $100 million per year in Shuttle operations support costs within the Air Force, make use of ELVs far more cost effective.

The final major factor in the decision was manifest flexibility. The Shuttle is a versatile vehicle with unique capabilities. However, scheduling flights on the Shuttle is a complicated and fairly rigid process. Given the pressures on the NASA manifest from missions such as Magellan, Galileo, Hubble Space Telescope, Ulysses, etc., and the long lead times for crew training and flight timeline development, it is essentially impossible to plan to use the Shuttle for "launch on need" requirements. That is, payloads launched on the Shuttle must be committed to launch in a specific order and on a specific date as much as two years in advance. Failures of operational satellites that require responsive replenishment cannot be accommodated. Similarly, replacements for satellites that have exceeded their expected lifetimes but still are functioning satisfactorily must be launched regardless of the need, because there is little capability to delay a launch "until it is needed."

Although several of the foregoing factors may be alleviated by the mid-1990s, the DoD decisions on the Shuttle had to be made to support the launch requirements of the 1989-1993 period, when the backlog of satellites that are awaiting launch is flown-out and we return to regular deployments and replacements. The investments have been made to acquire the alternate launch vehicles, including Titan II, Titan IV, Titan IV/Centaur, Delta II, and Atlas II, and to modify the spacecraft to fly on these vehicles.

Among the lessons learned in preparation for transition of DoD payloads to the Shuttle and in subsequent reintegration onto expendable launch vehicles is that dual compatibility is a difficult, expensive, technical, and operational challenge. The satellites that are most suited to dual compatibility are those that have already flown (or were planned to fly) on both the Shuttle and ELVs in their present configuration. These are as follows:

a. Defense Satellite Communications System (DSCS). The DSCS III has flown with an inertial upper stage (IUS), and could be flown two-at-a-time with an IUS on either the Shuttle or Titan IV, in addition to the planned single launches on the Atlas II. The MLV-II analysis confirmed that it was more effective operationally to fly single launches from essentially a dedicated launch facility, as is the case with the Atlas II, than to fly two-at-a-time on either the Titan or the Shuttle. In addition, the direct costs were slightly less for the Atlas II, and the indirect costs for the Shuttle, mentioned above, were substantial. These indirect cost savings would be lost if the DoD retained the capability to launch DSCS on the Shuttle after 1991. The DoD is considering completing the integration to allow DSCS to be launched with an IUS on the Titan IV, and expects to make this decision before the end of FY 1989. Factors to be considered are cost, schedule, status of the operational constellation, availability of launch opportunities on the Titan IV, availability of an IUS to be kept in reserve, and the progress of the Atlas II program. Once all the DSCS III satellites have been modified with the integral apogee boost system required for launch on the Atlas II, dual compatibility will no longer be practicable.

b. Defense Support Program (DSP). The improved DSP is capable of launch on either the Shuttle or Titan IV, with an IUS to place it in its final orbit. It is close to the Shuttle/IUS margin in weight. The DoD plans to launch one DSP I satellite on the Shuttle, and will maintain dual compatibility at least through 1991. The cost to do so beyond 1991 would be substantial, including the indirect costs for continued secure operations (Controlled Mode) and continued integration of the satellite. Maintaining the satellite at a weight consistent with the present Shuttle payload limits will incur some capability risks as DSP evolves to meet the changing threat. However, the greatest risk for DSP would be in launch schedule uncertainty. DSP is programmed to be launched at least once each year, but actually launches occur on need without on-orbit storage. As indicated, the Shuttle cannot support a responsive launch-on-need operational concept.

c. Global Positioning System. GPS was planned to be deployed fully from the Shuttle. It is now scheduled to be launched on the Delta II and is being integrated to fly on

Atlas II as a backup. The present inventory of 28 procured satellites will be launched between now and 1995, at a rate of approximately five per year. The follow-on GPS Block-IIR satellites are being acquired through a competition, and the intended launch vehicle is an ELV. While it would be possible to require the contractor to develop and maintain the satellite dual-compatible, the Air Force has not budgeted to do so. In addition, since the upper stages for the Delta II and the Shuttle are different, maintaining a dual capability would require procuring extra upper stages, some of which would not be used.

As indicated above, there are no firm technical barriers to flying any of those three satellites on the Shuttle in the mid-1990s. However, the DoD believes there is no operational advantage in flying the Shuttle instead of an ELV, and little operational advantage in maintaining dual compatibility. Further, there are significant cost penalties in maintaining compatibility beyond 1991 because of Shuttle-related expenses, satellite integration, and upper stage differences. Other national security payloads that have moved from the Shuttle to ELVs have the same barriers to dual compatibility.

In many cases, the absence of an upper stage larger than the IUS has precluded future consideration of the Shuttle as a launch vehicle. In others, especially for west coast launch, the reduced performance of the Shuttle made the Shuttle unusable in the near term. Although it is possible that the Vandenberg Shuttle facilities could be reactivated and these payloads returned to the Shuttle following the availability of the Advanced Solid Rocket Motor (ASRM), it would be technically, financially, and operationally impractical to do so. Any present payloads will have been flying on the Titan IV from SLC-4E for several years, with its capability of up to 40,000 lb with the SRMU, and probably will have "outgrown" the maximum 32,000 lb capacity of the Shuttle with ASRM.

Therefore, the DoD has decided to use expendable launch vehicles for its operational satellite systems for the foreseeable future. The discussions above have addressed cost in general terms, and have been based on the assumption that the cost of a Shuttle launch should be calculated at $115 million (FY 86 $), in accordance with the existing NASA/DoD agreement which is valid through FY 1991. Using this figure, the actual direct flight costs to DoD for using the Shuttle and ELVs favor the ELVs by a small margin, not enough to allow a decision to be made based solely on cost. As indicated, there are significant indirect costs to the DoD associated with continued use of the Shuttle, and even for NASA the $115 million represents only part of the cost to the nation of the launch of a Shuttle. If there were excess Shuttle capacity expected in the mid-1990s, it might be appropriate to compare ELV launch costs with the marginal cost of a Shuttle flight, and the actual cost to the nation of the

marginal flight might be competitive with the ELV. However, the DoD is not aware of any NASA projections that show significant excess capacity in the mid-1990s. The decisions to move the DoD payloads off the Shuttle have been made with the advice and support of the NASA Office of Space Flight.

Alternatives for the Vandenberg Shuttle Complex (SLC-6)

The difficulties in returning to extensive use of the Shuttle by the DoD in the mid-1990s, as discussed above, have a direct bearing on the future utility of the Shuttle Launch Complex at Vandenberg AFB. The Vandenberg Launch Site was built by the Air Force at a cost of over $3 billion. It achieved Initial Launch Capability (ILC), but was placed in Minimum Facility Caretaker Status following the Challenger accident (prior to its first launch), because it was clear that it would not be used for Shuttle flights for several years. Caretaker status meant that the facilities were retained intact so that ILC could be regained within four years from go-ahead.

In 1988 the decision was made to convert to a "Mothball" status, wherein only essential maintenance would be performed on those facilities that were Shuttle-unique, and any facilities that could be used by NASA or other DoD programs would be turned over to those users at no cost. The DoD provided a summary of the Mothball actions to the Congress in 1988. As indicated earlier, the Air Force estimates that starting at the end of FY 1989 it could activate the facility for Shuttle use in four to six years at a cost of approximately $1 billion. The actual time and cost would depend on the status of the facility at go-ahead, and the changes that would be required to reach the NASA operational configuration at the time.

There appear to be five options for use of the SLC-6 complex (referring to the actual launch facilities and those assets that have been retained under the Mothball program for possible future Shuttle use): (1) refurbish the complex to launch Shuttle; (2) refurbish the complex to launch Shuttle-C (a NASA-proposed, unmanned cargo version of the Shuttle); (3) modify the complex to launch Titan IV (in lieu of building a new Titan IV/Centaur pad, SLC-7); (4) maintain the facility in Mothball Status until one of the family of Advanced Launch Systems (ALS) vehicles is available, then modify it for that vehicle; or, (5) maintain the complex in Mothball status indefinitely.

The requirement for additional Titan IV capacity for launches to polar orbit was identified early in the launch recovery program. The number of launches required in the late 1990s will exceed the capacity of two to three launches per year that can be supported from SLC-4 East. In addition, the vulnerability of SLC-4E to damage from an accident involving a

launch from SLC-4E or SLC-4W (Titan II pad), and the impacts to national security from an extended outage of SLC-4E, require a second launch facility to provide the resiliency needed for an assured launch capability. The Air Force began detailed requirements and concept definition in 1988. Although no FY 1989 funds can be expended on the proposed fourth Titan IV complex, known as SLC-7, the Air Force has continued to assess the capacity limitations on Titan IV and the alternatives to meet the validated launch requirements. The amendments to the FY 1990 budget defer the initial MILCON request until FY 1992 and delay the ILC for a second west coast pad by at least one year. The modification of SLC-6 for Titan IV use in lieu of a new construction program is an active candidate to provide this capability.

The five options for use of SLC-6 indicated above are:

1. Shuttle. The DoD has no requirement in the foreseeable future for manned, polar operations in space, and can meet its unmanned requirements with ELVs. The DoD is aware of NASA plans for an unmanned polar orbiting platform, but knows of no NASA plans for a manned polar facility. Therefore, there appears to be no requirement or justification to begin the process of refurbishing the complex for Shuttle use--which would have to begin soon if the complex were to be available in the mid-1990s. We believe the congressional direction to Mothball the facilities recognized this, since it would make no sense to dispose of the Shuttle assets if it were intended to use them in the near future (i.e., mid-1990s).

2. Shuttle-C. There is no funding in the FY 1990 budget for Shuttle-C, and currently the DoD has no requirement for unique capabilities of Shuttle-C. The only DoD requirement during the next 15 years for launch to polar orbit that cannot be met with the present family of ELVs (with evolutionary modifications to improve performance or efficiencies and possibly the introduction to the west coast of a medium launch vehicle in the 7,000-10,000 lb class) is deployment of SDI. Full deployment of Phase II of SDI, as we know it today, would require a heavy lift vehicle, capable of sustained rates of up to ten flights per year. It is not clear that Shuttle-C would have the lift capacity or the launch rate capability for a Phase II SDI deployment. The DoD believes that any near-term requirement for a Shuttle-C capability must come from NASA and that the decision on use of SLC-6 should be based on validated, funded programs.

3. Titan IV. The amended budget identifies modification of SLC-6 as the approach for the second west coast Titan IV pad. The FY 1990-91 budget and FYDP contain only enough funds to modify SLC-6, and not enough to build a new pad, SLC-7. However, it is the DoD's intent to review thoroughly the implications of modifying SLC-6 before doing any work that commits us to one path

or the other. The DSB Summer Study will be a major factor in that review, along with other studies being conducted within the Air Force. The FY 90 budget request is intended to provide the assets to perform the detailed technical, cost, and policy analysis and design work that would be applicable to both approaches. Once a decision on the site is made, detailed development efforts leading to modification or construction will begin. The Air Force has asked NASA for its views on permanently modifying SLC-6. NASA supported the need for a second west coast Titan IV complex, although it expressed serious reservations about permanently modifying SLC-6 to make it usable only by Titan IV, precluding the potential for future use for the Shuttle or Shuttle-C.

It is clear that a decision to modify SLC-6 for Titan IV use must be made in the context of the overall national space program, based on recommendations by the National Space Council with the full participation of the civil and national security sectors. With adequate planning, the modified SLC-6 could be reconverted for Shuttle use with five-to-six-year lead time. A decision to convert back to Shuttle use would necessitate either a new Titan pad being built at that time, or activation of a west coast ALS capability in the Titan class that could accommodate some of the Titan payloads. Since the lead time for a launch pad is six years, a decision now to modify SLC-6 for Titan use would probably preclude its use for the Shuttle until after the turn of the century, when a Titan IV or ALS complex begun in the mid-1990s would be available. By that time, the nation will probably be looking toward use of a new manned vehicle instead of the Shuttle, which was designed in the 1970s, and major changes would be needed in SLC-6 for the new system.

4. Advanced Launch System (ALS) or other new, large launch vehicle. The ALS is funded to maintain a strong technology program, with insufficient funding in the budget to begin Full-Scale Development (FSD) of any member of the ALS family of vehicles. The Defense Acquisition Board review in Spring 1991 will address the issue of the timing of an FSD program, and DoD will adjust the funding as appropriate in the FY 1992-97 Six-Year Defense Program. After more study and analysis, and most likely after the turn of the century, the DoD will probably field a new or substantially modified launch capability on the west coast, either for SDI deployment or because requirements for lower cost, higher reliability and capacity, and better responsiveness make it cost effective to replace at least some of the present ELVs. If that system is larger than the Titan IV but smaller than the 200,000 lb class required for full SDI deployment, then the most likely launch sites available on South Vandenberg are SLC-6 and SLC-7. If SLC-7 is built for Titan IV, it is possible to make the design so that a 100,000 lb class ALS could use the same facility. If SLC-6 is used for Titan IV, the SLC-7 real estate would be available for a larger, future system. A third

alternative is to build SLC-7 for Titan IV and modify SLC-6 for a future, new system. Because the ALS is in the early phases of concept design, there is not enough known about the probable vehicle configurations to be confident about what size ALS could use SLC-6, or at what launch rates. The ALS Program Office will address these questions during its trade studies over the next two years.

The DSB will address the question of the appropriate role of the ALS program in the context of the overall future acquisition strategy and technology investment.

5. Retain in Mothball Status. Leaving the facility in Mothball status for many years preserves the option for Shuttle or Shuttle-C or ALS, but effectively precludes ever using the facility for Titan IV, since hardware work needs to begin on either modifying SLC-6 or building SLC-7 by the beginning of FY 1991 to meet the Titan capacity requirements. The DoD believes that to do nothing with the complex would be a mistake. The launch facility is too good and real estate on South Vandenberg is too valuable to leave the facility unused forever.

DoD Plans to Provide Assured Access To Space through 1995 and Beyond

The DoD recently delivered the National Space Launch Plan, approved by the President, to the Committees on Armed Services of the Senate and House of Representatives as well as to the Appropriations Committees of both Houses. The plan provides a detailed description of the DoD plans for assured access, and the limitations on achieving that goal. Specific program plans for each DoD launch vehicle and DoD payload, as well as an extensive review of the launch policy and strategy, are also included.